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Of the STRENGTH *of* ACIDS, *and the* PROPORTION *of* INGREDIENTS *in* NEUTRAL SALTS. *By* RICHARD KIRWAN, *Eſq; F. R. S. and M. R. I. A.*

Read Dec. 24, 1790.

THE ſcience of nature undoubtedly owes its origin ſolely to obſervation and experiment. But when it hath made a certain progreſs, the knowledge already acquired becomes a powerful inſtrument for making ſtill greater advances. This is evident in the chemical as well as in the mechanical branches of this ſcience. Hence its cultivation preſents a double object, viz. either the application of the powers already gained to the arts ſubſervient to human uſes, or the improvement of the inſtrumentality or power itſelf by which ſuch diſcoveries are effected. The merit of the former, if ſucceſsful, is undoubtedly the moſt apparent and ſtriking; but that of the latter is no leſs ſolid, and the neceſſary proceſſes infinitely more delicate. The ſucceſs of the former is often due to chance, the deſign of the latter is to diminiſh and finally to annihilate all dependence on chance. In chemical reſearches, all diſcoveries, not merely fortuitous,

tuitous, are grounded on the known properties of the agents employed, among which acids and ſalts are by far the moſt univerſal; but to apply theſe with ſecurity, their quantity, proportion and ſtate, whether of concentration or dilution, ſhould be aſcertained with ſome degree of accuracy; this, however, is allowed to be a problem of great difficulty, and few have attempted to ſolve it. Not aware of the obſtacles it preſented, but fully ſenſible of its importance, it has attracted my attention, and employed much of my leiſure theſe ten years paſt. My firſt eſſays are already known to the public; their defects and imperfections were ſignified to me in the moſt obliging manner by Meſſrs. Morveau and Berthollet, men with whoſe merit no part of Europe can be unacquainted. The methods I have ſince contrived to remove theſe imperfections, or at leaſt to diminiſh the aggregate of errors, form the ſubject of this paper*.

§ 1. *Of the Proportion of Acid in the Mineral Acids.*

Of the Marine Acid.

100 cubic inches of marine acid air weigh as nearly as I could eſtimate 60 grs. barometer 29,6, thermometer 57°. 10 grs. of water abſorb 10 of this air, bar. 29,6, ther. 49°. The ſpirit of ſalt thus formed occupies the ſpace of 13,3 grs. nearly; hence

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* This paper was preſented laſt April, and would have been read, had it not been that Mr. Pouget's letter, on which much of this is grounded, had been miſlaid.

its ſpecific gravity is 1,500 nearly, and the ſpecific gravity of the pureſt marine acid in its condenſed ſtate is 3,03 *.

I COULD not obſerve whether the abſorption of this air produced heat; moſt probably it did, but this is no proof that the condenſation was greater than that found by calculation.

THE ſpecific gravity of the ſtrongeſt marine acid that can eaſily be procured and preſerved is 1.196. 100 parts of this will be found by calculation to contain about 49 of that whoſe ſpecific gravity is 1,500, and which I call the ſtandard of the marine acid. The error ariſing from condenſation will ſcarcely exceed 1 or 1,5 grs. per cent.; by mixing this ſpirit of ſalt with different proportions of water I have had the reſults from which the enſuing table is calculated.

Table

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* Let D= the denſity of a mixture, *m* the weight of the denſer ingredient, *d* its denſity, *l* the weight of an equal bulk of water, and *m'*, *d'* and *l'* the ſame elements of the rarer. Then $D=\frac{m+m'}{l+l'}$. In the above caſe $m+m'=20$, and $l+l'=13,3$, then $D=\frac{20}{13,3}=1,5$.

Now to find the ſpecific gravity of the condenſed marine acid air, the denſer ingredient, we have from the above equation, $l=\frac{m+m'-l'D}{D}=\frac{5}{1,5}=3,3$, and $d=\frac{m}{l}=\frac{10}{3,3}=3,03$, which differs but little from the reſult in my firſt paper. But a miſtake of mere inadvertance had crept into the ſubſequent calculation, 1562 having been taken for 1502, and in conſequence 122 was inſerted inſtead of 62. Thus inſtead of 1562—1440=122, it ſhould be 1502—1440=62.

Then $m'=1440$. $l'=\frac{1440}{1,225}=1175,51$. $m=62$. $l=\frac{62}{3,1}=20$. then D or the denſity of the mixture $=\frac{1502}{1195,51}=1,256$, nearly the ſame as in my firſt paper.

Table of the Quantity of Standard Acid 1,500 *in Spirit of Salt of inferior Denſity. Temperature* 60°.

100 Parts.	Parts Standard.	100 Parts.	Parts Standard.	100 Parts.	Parts Standard.
1,196	49	1,147	37	1,1026	26
1,191	48	1,1414	36	1,0984	25
1,187	47	1,1396	35	1,0942	24
1,183	46	1,1358	34	1,0910	23
1,179	45	1,1320	33	1,0868	22
1,175	44	1,1282	32	1,0826	21
1,171	43	1,1244	31	1,0784	20
1,167	42	1,1206	30	1,0742	19
1,163	41	1,1168	29	1,0630	16
1,159	40	1,1120	28	1,0345	10
1,155	39	1,1078	27	1,0169	5
1,151	38				

To find the fractions between any two quantities of ſtandard in the table *, as far as one decimal place, find the difference between the denſities correſponding to the integral quantities of ſtandard, and divide that difference by 10. This gives a quotient which added ſucceſſively to the lower denſities or ſubſtracted from the higher, gives the denſities correſponding to the intermediate mixt quantities of ſtandard.

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* Though the formation of this table coſt me much more trouble than any of the ſucceeding, yet I fear it is much more imperfect, as in the ſucceſſive examination of the denſities my balance was frequently deranged by the repeated action of the fumes of the acid.

Of the Vitriolic Acid.

It was obſerved to me ſome years ago by the very able and candid philoſophic chemiſt, Mr. De Morveau, that the denſities accruing to mixtures of this acid with water, greater than found by calculation, ſhould principally be aſcribed to the condenſation of the aqueous part, rather than to that of the acid part, as I had done. I felt the juſtice of this obſervation, which ſubverted the inferences on which I had grounded my former calculations. I was, however, much embarraſſed to find a more unexceptionable method of forming tables on which I was ſenſible much of the preciſion requiſite in chemical analyſes depended, until I attended to Mr. Pouget's curious letter, lately read to the Academy *. I neither could make nor procure oil of vitriol whoſe ſpecific gravity is 2,000 in the temperature of 60°. Yet in cold climates this acid has frequently been produced; and as it is the ſtrongeſt or nearly ſo than can be exhibited by art, I take it as the ſtandard of the ſtrength of all other acids of this kind. From the multitude of experiments I have made with acids of inferior denſity, as 1,8846, 1,8689, 1,8042, 1,7500, I have reaſon to think that the condenſation of equal weights of this ſtandard acid and water amounts to $\frac{1}{7,5}$ of the whole. Then by the applications of Mr. Pouget's formulas for inveſtigating the accrued denſities of inferior proportions of acid and water, the ſucceſſive increments of denſity will be found as follows:

Parts

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* And now publiſhed in the Tranſactions for 1789.

Parts Water.	Standard.	Increments of Denſity.
5	95	,0252
10	90	,0479
15	85	,0679
20	80	, 856
25	75	,0699
30	70	,1119
35	65	,1213
40	60	,1279
45	55	,1319
50	50	,1333

By adding theſe increments to the ſpecific gravities found by calculation, and taking arithmetical mediums for the intermediate quantities of ſtandard, I made out the firſt fifty numbers of the following table; the remainder was formed by actual obſervation in the following manner, premiſing that the ſpecific gravities were always taken between 59,5° and 60°, or at moſt 60,5° of Farenheit.

1ſt, I found by the preceding part of the table that 100 parts oil vitriol whoſe ſpecific gravity was 1,8472 contained 88,5 parts ſtandard; conſequently 400 grs. of this acid contain 354.

2d, I then took 6 portions of this acid, each containing 400 grs. and added to them as much water as made them contain reſpectively 48. 46. 44. 42. 40. and 38. grains ſtandard.

To find the proportion of water that ſhould be added to each portion of acid, in order that it ſhould contain the given proportion of ſtandard, I uſed the following analogy: let the quantity of water to be added to 400 parts of the acid that the mixture may contain 48 per cent. ſtandard be x.

Then $400+x.\ 354 :: 100.\ 48$, then $19200+48x=35400$.

And $48x=35400-19200=16200$. And $x=\frac{16200}{48}=337{,}5$

In this manner I found the quantities of water to be added to each of the other portions. The mixtures being made, they were ſet by for four days, ſtirring them with a glaſs rod (that remained in them) each day, and the 5th day they were tried; after which the half of each was taken out and as much water added to them, and then ſet by for three days, by which means the ſpecific gravities correſponding to 24. 23. 22. 21. 20. and 19. per cent. ſtandard were found, after which 6 more portions of 400 grs. each of the concentrated acid, whoſe ſpecific gravity was 1,8393, were taken the proper proportion of water added to each, and after three days reſt and repeated agitation, their denſities in temperature 60° were examined as above, by which means the ſpecific gravities correſponding to 36. 34. 32. 30. 28. and 26. per cent. ſtandard were obtained, and half theſe portions mixed with half water exhibited, after three days reſt and agitation, the denſities correſponding to 18. 17. 16. 15. 14. and 13. per cent. ſtandard in the above temperature. The balance I uſed turned with $\frac{1}{32}$ of a grain when charged with two ounces, and the ſolid employed was a ſmall glaſs ball containing mercury which loſt 27,88 grs. of its weight when weighed in water in temperature 56°, ſuſpended commonly by a horſe-hair, but when dipped in ſtrong nitrous and marine acids it was ſuſpended by a fine gold wire, and then loſt 27,78 grs. of its weight in water.

I ALSO examined and rectified, in ſome inſtances, many parts of the firſt 50 numbers of the table in the ſame manner, but in general I found them juſt.

Table of the Quantity of the ſtandard vitriolic Acid 2,000 *in Oil or Spirit of Vitriol of inferior Denſity.*

100 Parts.	Standard Temperature 60°.	100 Parts.	Standard.	100 Parts.	Standard.
2,000	100	1,6217	67	1,2847	34
1,9859	99	1,6122	66	1,2757	33
1,9719	98	1,6027	65	1,2668	32
1,9579	97	1,5932	64	1,2589	31
1,9439	96	1,5840	63	1,2510	30
1,9299	95	1,5748	62	1,2415	29
1,9168	94	1,5656	61	1,2320	28
1,9041	93	1,5564	60	1,2210	27
1,8914	92	1,5473	59	1,2101	26
1,8787	91	1,5385	58	1,2009	25
1,8660	90	1,5292	57	1,1918	24
1,8542	89	1,5202	56	1,1836	23
1,8424	88	1,5112	55	1,1746	22
1,8306	87	1,5022	54	1,1678	21
1,8188	86	1,4933	53	1,1614	20
1,8070	85	1,4844	52	1,1531	19
1,7959	84	1,4755	51	1,1398	18
1,7849	83	1,4666	50	1,1309	17
1,7738	82	1,4427	49	1,1208	16
1,7629	81	1,4189	48	1,1129	15
1,7519	80	1,4099	47	1,1011	14
1,7416	79	1,4010	46	1,0955	13
1,7312	78	1,3875	45	1,0896	12
1,7208	77	1,3741	44	1,0833	11
1,7104	76	1,3663	43	1,0780	10
1,7000	75	1,3586	42	1,0725	9
1,6899	74	1,3473	41	1,0666	8
1,6800	73	1,3360	40	1,0610	7
1,6701	72	1,3254	39	1,0555	6
1,6602	71	1,3149	38	1,0492	5
1,6503	70	1,3102	37	1,0450	4
1,6407	69	1,3056	36	1,0396	3
1,6312	68	1,2951	35	1,0343	2

THE laſt eleven numbers were only found by analogy, obſerving the ſeries of decrements in the four preceding denſities, and therefore are to be conſidered barely as approximations.

To reduce vitriolic acids of given denſities at any degree of temperature between 49° and 70° to that which they ſhould have at temperature 60°, in order that their proportion of ſtandard may be thereby inveſtigated, I made the following experiments:

Degrees of Temperature.	Sp. Gr. of A.	Sp. Gr. of B.	Sp. Gr. of C.
70°	1,8292	1,6969	1,3845
65°	1,8317	1,6983	1,3866
60	1,8360	1,7005	1,3888
55	1,8382	1,7037	1,3898
50	1,8403	1,7062	- -
49	1,8403	- -	1,3926

HENCE we ſee that vitriolic acid, whoſe denſity at any degree between 49° and 70° reſembles or approaches the correſponding denſity in the column A, gains or loſes 0,00126 of its ſpecific gravity by *every two* degrees between 60° and 70° of Farenheit, and 0,00086 by *every two* degrees between 49° and 60°.

Secondly, that any vitriolic acid, whoſe denſity at any degree between 50° and 70° reſembles or approaches to the correſponding denſity in the column B, gains or loſes 0,00158 for every two degrees between 60° and 70°; and 0,0017 by every two degrees between 50° and 60°. Whence it appears that the ſtronger acid is leſs altered by variation of temperature than the weaker, which formerly appeared to me an irregularity, but now ſeems to proceed from the increaſe of the accrued denſity, when larger proportions of water are mixed with the ſtronger acid.

Thirdly, vitriolic acid, whoſe denſity at any degree between 50° and 70° reſembles the correſponding at the ſame degree in the column C, gains or loſes, 0,00086 for every two degrees between 60° and 70° incluſively, and, 0,00076 between 50° and 60°. Between 45° and 50° I could perceive no difference.

Of the Nitrous Acid.

THE ſpecific gravity of the moſt concentrated nitrous acid I could produce was 1,5543 in the temperature of 60°: It was of a yellowiſh red colour, and ſo highly phlogiſticated and volatile, that it was impoſſible to make accurate experiments upon it, when mixed with ſmall proportions of water; but when mixed with an equal weight I found its encreaſe of denſity to be about $\frac{1}{12}$ of the whole. Hence I formed the firſt fifty numbers of the ſubſequent table by calculation, according to Mr. Pouget's formula, and the remainder by experiments, conducted, as already mentioned in treating of the vitriolic acid. The temperature at which the denſities were examined was always between 59,5° and 60°, ſeldom 60,5°. The acid I uſed was the pale yellow acid, whoſe ſpecific gravity was 1,4099, but the firſt I conſidered as the ſtandard.

Table

Table of the Quantity of Nitrous Acid whoſe Denſity is 1,5543 *in Spirit of Nitre of inferior Denſities. Temperature* 60°.

100 Parts.	Parts Standard.	100 Parts.	Parts Standard.	100 Parts.	Parts Standard.
1,5543	100	1,4018	70	1,2586	44
1,5295	95	1,3975	69	1,2525	43
1,5183	94	1,3925	68	1,2464	42
1,5070	93	1,3875	67	1,2419	41
1,4957	92	1,3825	66	1,2374	40
1,4844	91	1,3775	65	1,2291	39
1,4731	90	1,3721	64	1,2209	38
1,4719	89	1,3671	63	1,2180	37
1,4707	88	1,3621	62	1,2152	36
1,4695	87	1,3571	61	1,2033	35
1,4683	86	1,3521	60	1,2015	34
1,4671	85	1,3468	59	1,1963	33
1,4640	84	1,3417	58	1,1911	32
1,4611	83	1,3366	57	1,1845	31
1,4582	82	1,3315	56	1,1779	30
1,4553	81	1,3264	55	1,1704	29
1,4524	80	1,3212	54	1,1639	28
1,4471	79	1,3160	53	1,1581	27
1,4422	78	1,3108	52	1,1524	26
1,4373	77	1,3056	51	1,1421	25
1,4324	76	1,3004	50	1,1319	24
1,4275	75	1,2911	49	1,1284	23
1,4222	74	1,2812	48	1,1241	22
1,4171	73	1,2795	47	1,1165	21
1,4120	72	1,2779	46	1,1111	20
1,4069	71	1,2687	45	1,1040	19

As the ſpecific gravity of the nitrous acid varies conſiderably in different temperatures, to find the connexion which its denſity at any temperature between 45° and 70° has with its denſity at 60°, and thereby to diſcover its proportion of ſtandard, I made the following experiments:

Degree of Temperature.	Sp. Gr. of A.	Sp. Gr. of B.
70°	1,4178	1,2320
65	1,4225	1,2342
60	1,4279	1,2363
55	1,4304	1,2384
50	1,4336	1,2406
45	1,4357	1,2417

1ſt, Hence we ſee that ſpirit of nitre, whoſe denſity at any degree between 45° and 70°, incluſively, reſembles the correſponding denſities at the ſame temperatures in the column A, gains or loſes 0,00107 by *every degree* between 60° and 70°.

And 0,00057 by *every degree* between 50° and 60°.

And 0,00042 by *every degree* between 45° and 50°.

2d, That ſpirit of nitre, whoſe denſity at any degree between 45° and 70° reſembles the correſponding denſities at the ſame temperature in the column B, gains or loſes 0,00043 by *every degree* between 50° and 70°.

And 0,00022 by *every degree* between 45° and 50°.

§ 2. *Of the Proportion of Ingredients in Neutral Salts formed with common Mineral Acids.*

THIS problem involves all the difficulties of the former, beſides ſome that are peculiar to it. For ſuppoſing the proportion of acid to be given, it ſtill remains to determine the ſtrength of that acid, elſe the word preſents no definite meaning. This can be done only by reference to ſome known ſtandard. The chemiſts whoſe inquiries have preceded or accompanied mine, have conſidered the acid retained by neutral ſalts in a red heat as the *ſtrongeſt poſſible*. But unleſs all theſe ſalts poſſeſs the ſame power of retaining acids in a red heat, this term muſt have a different ſignification when applied to each, and conſequently preſent no determinate idea. Now it is well known that different neutral ſalts poſſeſs this power in different degrees; beſides the term *red heat* is a term of great latitude, and comprehends degrees of heat very diſtant from each other.

THE determination of the proportion of water in theſe ſalts, on the ſuppoſition that they all neceſſarily contain ſome, is attended with nearly the ſame difficulties. It has generally been ſuppoſed that the weight loſt by neutral ſalts when expoſed to a red heat, expreſſed the quantity of water of cryſtallization, but it is now known that ſome of them loſe part of their acid as well as their water in that heat, to ſay nothing of the difficulty of conſtantly employing the ſame exact degree in all caſes, or if it could be employed, of ſuppoſing that they all poſſeſs the ſame power of retaining the aqueous part. Even the ancient opinion, that cryſtallization neceſſarily implies the preſence and retention of water, is deſtitute of foundation, ſince it is now known that cryſtals may be formed in the dry way; even many of thoſe formed in the moiſt way, as moſt ſtoney cryſtals, retain no perceptible quantity of the liquid in which they were formed.

DETERMINED by theſe conſiderations, I have abandoned in a great meaſure the antient method, and have ſubſtituted the following: Firſt, I ſaturate a known quantity of alkali or other baſis with an acid whoſe ſpecific gravity is known, and whoſe proportion of ſtandard is determined by the tables. I then make another ſolution of a known quantity of neutral ſalt of the ſame ſpecies as that formed by ſaturation, and examine the ſpecific gravity of both ſolutions in the ſame temperature, adding water to the ſtronger of the two, until their denſities become equal, and thence infer that an equal proportion of ſalt exiſts in both, but the proportion in one of them is known; and therefore the proportion in the other, the weight of the whole being found, is alſo determined. Even this method is ſubject to a ſmall inaccuracy, for a ſlight exceſs of acid is always left, leaſt any loſs of liquor ſhould enſue from trials of ſaturation with vegetable blues, and this renders the denſity of the ſolution of the regenerated ſalt ſomewhat greater than would enſue from the proportion of ſalt it contains, beſides that in many caſes the proportion of water of cryſtallization muſt be diſcovered by expoſure to heat.

Of Tartar Vitriolate.

MY firſt care was to procure a pure vegetable alkali; with this view I burned a quantity of cream of tartar in a ſilver crucible, and after ſolution, filtration and evaporation, to dryneſs in a red heat, I found the alkali to weigh 1523,5 grs. This I diſſolved in diſtilled water, the whole then weighed 4570 grs. Of this ſolution I took 360 grs. which contain 120 of mild alkali and ſaturated it with oil of vitriol carefully purified, whoſe ſpecific gravity was 1,565, and which by my table contains 61 per cent. ſtandard acid; the quantity employed amounted to 130 grs. which contained 79 ſtandard. The fixed air expelled amounted to 34 grs. and therefore the quantity of real alkali was 120−34=86 grs. The ſolution being turbid I diluted it with more water; when 3238 were added, its ſp. gravity was 1,013, temperature 60°, the whole weight was 360+130+3238−34=3694 grs. 45 grs. of tartar vitriolate diſſolved in 1017 of diſtilled water had the ſame ſp. gravity, temperature 60°. Hence the proportion of ſalt in each ſolution was equal. But in this laſt the quantity of ſalt was $\frac{1}{23,6}$, then the quantity of ſalt in the former was $\frac{3694}{23,6}$=156,52 grs. Now of this quantity only 86 were alkali, therefore the remainder, viz. 70,5, were acid or acid and water. The quantity of acid employed in the ſaturation contained 79 grs. ſtandard, but the acid taken up amounted only to 70,5 grs. therefore 8,5 were rejected, and conſequently were mere water, therefore the acid taken up is ſtronger than ſtandard; and ſince 79 parts ſtandard loſe 8,5 by union with pure vegetable alkali, 100 parts ſtandard ſhould loſe 10,75. or 89,25 parts of acid of the ſtrength of that which unites to veg. alkalies, and is found in tartar vitriolate; contains as much real acid as 100 parts ſtandard. And hence 100 parts of this ſtrong acid are equivalent to 112 of ſtandard. Therefore 100 parts cauſtic dry veg. alkali take up nearly 92 of ſtandard vitriolic acid, or 82 nearly of the ſtrongeſt vitriolic acid, and afford 182 of tartar of vitriolate in its common dry cryſtallized ſtate. This laſt concluſion is the moſt certain, being independent of any error in the calculations of the table.

100 parts tartar vitriolate contain 55 of mere alkali and 45 of the ſtrongeſt acid, equivalent to about 50,42 of ſtandard.

HENCE there is no reaſon to ſuppoſe that this ſalt contains any water of cryſtallization, but rather the contrary. In a heat below ignition it loſes no part of its weight, and in a red heat continued for half an hour it falls into powder, but 100 grs. loſt only one, which might have been diſſipated or have been only ſome accidental moiſture or impurity, or part of its acid. Mr. Storr remarked that it loſt no water of cryſtallization in any degree of heat under 590. 2 Nev Entdeck. 227.

To compare the reſults of this mode of inveſtigation with thoſe of that which I formerly uſed, I evaporated the ſaturate ſolution to dryneſs, uſing at the end a heat of 360°. The ſalt thus formed weighed 158 grs. which increaſe of weight may be owing to duſt fallen in during the evaporation. I alſo made a few experiments to aſcertain the accuracy of my table, of which

I ſhall relate only one. To 654,5 grs. of the ſolution of the vegetable alkali which contained 218,16 of mild alkali, I added oil of vitriol, whoſe ſpecific gravity was 1,5045, and conſequently contained 54 per cent. ſtandard, and of this I found that 270 grs. were requiſite to ſaturate the alkali, with a ſmall exceſs of acid as uſual. The air diſengaged amounted to 61,8 grs. conſequently the quantity of pure alkali was 156 grs. the quantity of ſtandard in that of the oil of vitriol employed was 145,8 grs. and if 156 of alkali take 145,8 of vitriolic ſtandard, 100 of the alkali ſhould take 93 ſtandard.

As this ſubject is intimately connected with many others of great importance, ſuch as the analyſis of mineral waters, the theory of dying, the cauſes of cryſtallization, deliqueſcence, refrigerating powers, and ſolubility of neutral ſalts, both in water, and ſpirit of wine, I ſhall ſubjoin the different reſults of the few chemiſts that have attended to this object, with ſome remarks to enable the chemical reader to form his judgment thereupon.

According to Mr. Bergman, 100 parts tartar vitriolate conſiſt of 52 pure alkali, 40 acid and 8 of water. At this rate 100 parts pure vegetable alkali take up about 77 of the ſtrongeſt vitriolic acid, yet he elſewhere ſays they take up 78,5. How he diſcovered ſo large a portion of water in the cryſtallized ſalt I cannot conjecture; Mr. Wenzel found that 240 grs. of it loſt but one in a red heat. Hence 100 parts pure vegetable alkali ſhould afford above 192 of tartar vitriolate.

Mr. Wenzel found that 83,5 grs. of pure dry vegetable alkali were exactly ſaturated by 218,75 grs. of ſpirit of vitriol; the ſolution being evaporated, and the reſiduum expoſed to a red heat, afforded him 152,5 grs. of tartar vitriolate. From whence he infers that this quantity contained 83,5 of mere alkali, and 69 of the ſtrongeſt vitriolic acid. By which it would appear that,

First. 100 parts pure vegetable alkali take 82,63 of the ſtrongeſt vitriolic acid, and afford 182,63 of tartar vitriolate.

Secondly. That 100 parts tartar vitriolate contain 54,75 of mere alkali, and 45,25 of the ſtrongeſt vitriolic acid. Both which concluſions agree as nearly as can be expected with mine; and as the methods employed were ſo widely different, this coincidence is a ſure mark that the error, if any, muſt be very trifling.

From the reſult of this experiment Mr. Wenzel eſtimates the quantity of the ſtrongeſt acid contained in half an ounce of his ſpirit of vitriol; for ſince 218,75 grs. of this ſpirit of vitriol contains 69 of the ſtrongeſt acid, 240 muſt contain 75,75, or (by my experiment) 75,13 of the ſtrongeſt acid, which are equivalent to about 84,19 of my ſtandard, and 100 grs. of it contained 38,4 of my ſtandard, its ſpecific gravity was therefore 1,3189.

Mr. Wiegleb repeated this experiment exactly in the manner of Bergman, and yet the reſult was very different, for he found that 52 grs. of the pure alkali took up 53 of the ſtrongeſt vitriolic acid, and the reſulting ſalt weighed 105 grs. From the known accuracy of this excellent chemiſt it muſt be preſumed that ſome circumſtance occurred ſimilar to that which occaſioned an increaſe of weight in my experiment.

Of Nitre.

I TOOK 360 grains of the ſame alkaline ſolution, and diluted it ſtill further by the addition of 622 of water, the whole containing as before 120 grs. of mild vegetable alkali. This I ſaturated with ſpirit of nitre whoſe ſpecific gravity was 1,1316, and for that purpoſe 436 grs. were required. This acid contains by my table 23,9 grs. ſtandard nearly; then the quantity employed contained 104. The loſs of air was 34 grs.; and hence the quantity of pure alkali was 86 grs. After the ſolution had ſtood fourteen hours I found its ſpecific gravity, temperature 58°, to be 1,099. The whole weight was 1384 grs.

I THEN took 720 grs. of diſtilled water, and gradually adding cryſtallized nitre finely pulverized and dried by long expoſure to the air, I found that when 112 grs. of it were diſſolved the ſpecific gravity of the ſolution was 1,099 in the ſame temperature as above, therefore the proportion of nitre was the ſame in both, that is $\frac{1}{7{,}428}$ part of each. Now $\frac{1384}{7{,}428} = 186{,}32$, this then was the quantity of regenerated nitre.

In this experiment as in the former the quantity of pure alkali was 86 grs. the quantity of ſtandard 104 grs. the ſum of both 190 grs. yet the quantity of nitre was only 186,32 grs. Hence 3,68 are rejected as mere water; and if 104 ſtandard loſe 3,68, 100 parts ſtandard ſhould loſe about 3,5; and hence the acid that enters into nitre is ſtronger than ſtandard in the proportion of 103,5 to 100 nearly, or 100 parts of this acid are equivalent to 103,5 of ſtandard nearly. And therefore,

First. 100 grains pure vegetable alkali ſaturated with nitrous acid ſhould afford about 216 of nitre, and take up about 116 of the ſtrongeſt nitrous acid, equivalent to 120 of the nitrous ſtandard.

Secondly. 100 parts cryſtallized nitre contain 46,15 of alkali, and 53,85 of acid ſtronger than ſtandard in the proportion above-mentioned.

Having evaporated the ſaturated ſolution, and expoſed it to a heat of 360°, I found the reſiduum to weigh no more than 179 grs. ſo that 7 grs. were loſt. Indeed the ancient method is in no caſe more defective than when applied to nitre, for during evaporation part of it is carried off, as Wallerius long ago remarked, and when expoſed to a red heat part of the acid is loſt, and hence the great difference of the reſults heretofore obtained. As to water of cryſtallization we may be aſſured that it contains none. Mr. Storr, who attended particularly to this object, found that it retains its cryſtalline form, and only becomes turbid in a heat of 590°. He thinks, indeed, it loſes ſome when melted, but we now know it is the acid that eſcapes.

The proportion of ingredients aſſigned by Mr. Bergman to 100 parts of cryſtallized nitre is 49 of alkali, 33 of acid, and 18 of water. He does not ſeem aware of the loſs occaſioned by evaporation, nor was he at that time acquainted with the decompoſition of the acid occaſioned by ignition, both which circumſtances rendered his concluſions erroneous, as they did my own in my firſt publication. The loſs occaſioned by this laſt circumſtance he probably attributed to the eſcape of water, and thence aſſigned ſo large a proportion of this principle. According to him it ſhould follow that 100 parts pure alkali take up 67,34 of the ſtrongeſt nitrous acid and afford 204 of nitre, yet elſewhere he aſſerts that 100 parts pure vegetable alkali take up but 64 of the ſtrongeſt nitrous acid.

Mr. Wenzel's determination is more exact; he found that 83,5 grs. of pure vegetable alkali were ſaturated by 262 of his ſpirit of nitre, and that the ſalt thus formed after evaporation and expoſure to a mild red heat weighed 173,5 grs. and thence inferred that 173,5 grs. of ignited nitre contained 83,5 of alkali and 90 of the ſtrongeſt nitrous acid, conſequently 100 parts nitre contain about 48 of alkali and 52 of acid. This reſult approaches much nearer to the truth than that of Mr. Bergman, as it aſſigns a larger proportion of acid than of alkali, which the quantity of air expelled from nitre evidently proves, and from this it ſhould follow that 100 parts of pure alkali take up about 108 grs. of the ſtrongeſt nitrous acid, and afford 208 grs. of nitre, or ſomewhat

what more of cryſtallized nitre; for he thinks that 240 grs. of theſe cryſtals loſe 2 of water when ignited, which ſhews that his red heat was much milder than that applied by Mr. Bergman, and explains the difference of their reſults when they followed in appearance the ſame method of inveſtigation.

SINCE 100 parts pure alkali take up 116 of the ſtrongeſt nitrous acid, 83,5 take up 96,86, which are equivalent to 100,25 of ſtandard. This quantity of ſtandard muſt therefore have been contained in the 262 grs. of the ſpirit of nitre employed by Mr. Wenzel in ſaturating 83,5 of pure alkali, whence it follows that 100 grs. of his ſpirit of nitre contained 38,22 of my ſtandard; its ſpecific gravity was then about 1,227 *.

MR. Wiegleb's ſucceſs was ſtill more complete; he found that 112 grs. of nitre gently heated contained 52 of alkali and 60 of the ſtrongeſt acid; and conſequently 100 grs. of nitre contain 46,5 of alkali and 53,5 of acid nearly, which agrees almoſt exactly with my determination. Hence 100 parts pure alkali ſhould take up 115,4 of the ſtrongeſt acid and afford 215,4 of nitre.

Salt of Sylvius or muriated Vegetable Alkali.

To 360 grs. of the ſolution of mild vegetable alkali, ſtill further diluted by the addition of 518 grs. of water, I added ſpirit of

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* His own concluſion is, that 240 grs. of his ſpirit of nitre contain 82,5 of the ſtrongeſt acid of nitre, which are equivalent to 91,72 of my ſtandard.

of ſalt whoſe ſpecific gravity was 1,1466. The quantity neceſſary for ſaturation was 254 grs. the loſs of air amounted to 34. The ſpecific gravity of the ſaturate ſolution in the temperature of 56° was 1,076, the whole weight 1098 grs.

The ſpecific gravity of a ſolution of 100 grs. of ſalt of ſylvius in 720 of water in temperature 56° was alſo 1,076, hence the proportion of ſalt in both ſolutions was equal, viz. $\frac{1}{8,2}$ of the whole. Now $\frac{1098}{8,2} = 113,902$, of this quantity 86 were pure alkali, therefore the remainder, conſiſting of 47,902 grs. were acid or acid and water. But as this ſalt when apparently dry loſes at moſt 3 per cent. in a red heat, I conſider it to contain no water of cryſtallization, and conſequently judge thoſe 47,902 grs. to be acid. Now 254 grs. of this ſpirit of ſalt contain 92,71 of ſtandard. And of theſe it appears that only 47,902 were taken up, therefore 44,908 are rejected as mere water, and if 92,71 loſe 44,908, it follows that 100 grs. ſtandard ſhould loſe, on uniting to pure vegetable alkali, 48,4 grs. and conſequently is nearly as dephlegmated as marine air.

Hence 48,4 grs. of this ſtrong acid are equivalent to 100 grs. of ſtandard, or 100 of this ſtrong acid to 206 of ſtandard; 100 grs. therefore pure vegetable alkali take up 55,7 of this ſtrongeſt marine acid, which are equivalent to 115 nearly of ſtandard, and afford 155,7 grs. of ſalt of ſylvius.

2dly, 100 grs ſalt of ſylvius contain 64,2 of alkali, and 35,8 of the ſtrongeſt marine acid, equivalent in ſtrength to 73 nearly of ſtandard. Mr. Storr aſſerts, that it ſuffers no loſs of weight in a heat below 590°.

The proportion aſſigned by Mr. Bergman to 100 parts of this ſalt is 61 of alkali, 31 of acid, and 8 of water. Hence by him 100 parts pure vegetable alkali take up 50,82 of ſtrongeſt marine acid, and afford about 164 of ſalt of ſylvius.

Mr. Wenzel's reſult ſcarcely differs from mine; he found that 83,5 grs. of pure alkali were ſaturated by 202 of his ſpirit of ſalt, and that the reſiduum after evaporation and expoſure to a red heat weighed 129 grs.; of theſe 83,5 were alkali, and therefore the remaining 45,5 were acid.

Hence, 1ſt, 100 parts pure vegetable alkali afford by his experiment 154,5 of ſalt of ſylvius, and take up 54,5 of the ſtrongeſt marine acid.

2dly, 100 parts of this ſalt contained 64,42 of alkali and 35,58 of acid. When this ſalt is cryſtallized, he thinks that 240 grs. of it contain 8 of water, as they loſe ſo much in a red heat; but it is probable that this loſs is rather occaſioned by the diſperſion of the ſalt, or the loſs of part of its acid, and ſome ſmall portion of water not neceſſarily belonging to its conſtitution; and this ſeems confirmed by his experiment, for 83,5 parts of pure alkali ſhould, by my determination, take up 46,5 of the ſtrongeſt acid, whereas in his experiment they took only 45,5, which decreaſe may well be attributed to the ſtrong red heat he employed, for his ſalt was melted.

HENCE, 3dly, we may eſtimate the ſtrength of his ſpirit of ſalt; for ſince 202 grs. of it contained 46,5 of the ſtrongeſt acid, which are equivalent to 96 of ſtandard, 100 parts of it muſt contain 47 of ſtandard, and conſequently its ſpecific gravity was about 1,1892*.

IT is moſt probably to the great heat employed that we muſt aſcribe the difference between all the above reſults and that of Mr. Wiegleb, for he found that 104 grs. of ſalt of ſylvius contained 83 of alkali and only 21 of the ſtrongeſt acid.

Of Glauber's Salt.

A QUANTITY of cryſtallized mineral alkali being evaporated to dryneſs, and then heated to redneſs in a ſilver crucible, was diſſolved in pure water in ſuch proportion that 367 grs. of the ſolution held 50,05 of dry mild alkali.

ON 367 grs. of this ſolution I gradually poured 75 grs. of vitriolic acid, whoſe ſpecific gravity was 1,565, and which contains 61 per cent. ſtandard; the loſs of air was 18 grs. and when it was ſtill further diluted by 480 grs. of water, its ſpecific gravity, temperature 55°, was 1,0670, which by a ſtandard experiment, ſimilar to thoſe already mentioned, I found to denote that $\frac{1}{6,825}$ of its weight was ſalt. The whole weight was 904 grs. then $\frac{904}{6,825}=132,45$, the quantity of ſalt, the quantity of pure alkali was 50,08—18=32,05, that of ſtandard acid was 45,75, the ſum of both was 77,83, and the remainder 54,62 muſt be the water of cryſtallization, or that which is ſuperfluous to the ſtandard.

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* His own concluſion is, that 240 grs. of his ſpirit of ſalt contain 54 of the ſtrongeſt acid.

HENCE, 1ſt, 100 parts pure mineral alkali take up 143 nearly of ſtandard, and ſhould afford 414 of dry cryſtallized Glauber.

2d, 100 parts cryſtallized Glauber contain 24,16 of mere alkali, 34,54 of ſtandard acid, and 41,3 of ſuperfluous water; or if the ſalt be heated to dryneſs, 100 parts of it will contain 41 of alkali and 59 of ſtandard acid. It is true, that if this cryſtallized ſalt be heated ſtill further it will loſe more water, for I have found 100 parts to loſe 55, even when heated below ignition, but this proceeds partly from a loſs of the water inherent in the ſtandard acid, and partly from a loſs of the acid itſelf, for the vapours and laſt drop redden blue vegetable colours.

ACCORDING to Mr. Bergman, 100 parts of this ſalt contain 15 of alkali, 27 of the ſtrongeſt acid, and 58 of water; if ſo, 100 parts pure alkali ſhould take up 180 of the ſtrongeſt acid (though he elſewhere ſays only 177) and afford 666 of cryſtallized ſalt, or 280 of that deprived of its water of cryſtallization.

THERE IS a method of inveſtigating the proportion of ingredients in this ſalt, which I once purſued, and which afforded a reſult not very different from that of Mr. Bergman.

I CONSIDERED 100 parts of cryſtallized mineral alkali, to appearance perfectly dry, and yet not decompoſed, to conſiſt of 16 parts of fixed air, 20 of pure alkali, and 64 of water, as Mr. Bergman found them. However this proportion of fixed air in cryſtals to appearance perfectly dry and not effloreſced I often failed of finding. Sometimes this proportion was 12 per cent. ſometimes 13 or 14, and ſeldom 16 per cent. However, I imagined that the ſalt being perfectly cryſtallized neceſſarily required the ſame proportion of fixed air to the alkali, and that the deficiency aroſe from an exceſs of unperceived moiſture, which made up the weight of 100 parts; and therefore when I found a ſmaller quantity of fixed air in 100 parts of this ſalt, I inferred that it contained a ſmaller quantity of alkali, in the proportion of 16 to 20. So that if 16 parts of air indicated 20 of alkali, 12 of fixed air ſhould indicate 15 of alkali. I was even confirmed in this opinion by the following experiments. I found that 100 grs. of cryſtallized mineral alkali, which afforded 12 of fixed air, were ſaturated by 52 of vitriolic acid; but that another portion of the ſame alkali that emitted 13 grs. of fixed air required 56 of the ſame acid. Now 12.52::13.56 nearly. Again, I found that 100 parts of this alkali which gave out 15 of fixed air were ſaturated by 121 of marine acid, whereas another portion of the ſame alkali which contained but 13,5 of fixed air, took up but 108 of the ſame acid; and 15.13,5::121.109 nearly. It muſt be owned that this concluſion appeared ſufficiently probable, and under that impreſſion I made the following experiment.

HAVING diſſolved 100 grs. of cryſtallized mineral alkali in 720 of water, I ſaturated this ſolution with vitriolic acid, whoſe ſpecific gravity was 1,5654, and for this purpoſe 52 grs. were requiſite, the loſs of air was 12 grs. and hence I inferred the quantity of pure alkali to be 15 grs. the ſpecific gravity of the ſolution, temperature 65°, was 1,045, and its weight 860 grs. The acid contained 61 per cent. ſtandard.

I ALSO found the ſpecific gravity of a ſolution of 100 grs. cryſtallized Glauber in 836 of water to be 1,045 in the ſame temperature, and as this ſolution contained $\frac{1}{9,36}$ of its weight of ſalt, I inferred the former to contain the ſame proportion, and conſequently the quantity of ſalt to be $\frac{860}{9,36}=91,88$ grs. but of this quantity 15 only were alkali, and 31,72 ſtandard acid, =46,72, therefore the remainder was the water taken in by cryſtallizing =45,16 grs.

FROM hence it ſhould follow that 100 grs. cryſtallized Glauber ſalt contain 16,32 of alkali, 34,52 of ſtandard acid, and 49,15 of water, of cryſtallization, which nearly agrees with the determination of Mr. Bergman, for my ſtandard is undoubtedly weaker than what he calls his ſtrongeſt acid, and if we take 7 grs. from the ſtandard, and attribute them to the watery part, there will be but little difference. Yet I now believe this determination to be erroneous, as being different from the reſult of the firſt experiment, which is direct, and becauſe part of the acid eſcapes in a ſtrong heat. Different portions of a parcel of cryſtallized mineral alkali, which had effloreſced by expoſure to the air for ſixteen months, afforded different portions of fixed air; yet without particular attention we may often be deceived, as the ſaturated alkali frequently reſorbs a portion of the air it gives out, ſo that the contents of air cannot be exactly eſtimated by weighing, unleſs the ſaturate liquor be ſuffered to reſt for ſome hours expoſed to the air.

Mr. Wenzel having ſaturated 120 grs. of dry mild mineral alkali with his ſpirit of vitriol, found the loſs of air to be 48 grs. the quantity of ſpirit of vitriol expended 285,33 grs. the ſalt remaining after ignition 162 grs. or rather 161,5, as $\frac{1}{2}$ gr. of earth was precipitated, which muſt be deducted from the alkali. Hence the quantity of pure alkali was 71,5, which deducted from 161,5, gives the quantity, as he thinks, of the ſtrongeſt acid = 90 grs. Hence it ſhould follow,

That 100 parts pure mineral alkali take up 125,87 of the ſtrongeſt acid, and afford 225,87 of dry Glauber's ſalts.

He elſewhere remarks that 240 grains of cryſtallized Glauber loſe by ignition 134 grs. of water, conſequently 106 [=240—134] of the dried ſalt take up in cryſtallizing 134 of water, then 161,5 of the dried ſalt ſhould take up 204,16, and the ſum of both is 365,66, the quantity of cryſtallized ſalt produced in the above experiment.

HENCE, firſt, 100 parts pure mineral alkali ſaturated with vitriolic acid ſhould afford about 511 of chryſtallized Glauber.

SECONDLY. 100 parts of this cryſtallized ſalt contain 19,58 of alkali, 24,62 of the ſtrongeſt acid, and 55,8 of water.

THE principal defect of theſe experiments is, that he dried his alkali by fuſion in an earthen crucible, by reaſon of which the alkali took up both ſiliceous and argillaceous earth; the ſiliceous, indeed, was precipitated during the ſaturation with the acid, but the argillaceous was not, but on the contrary took up more of the acid than the pure alkali would have done. Hence he found a ſmaller proportion of alkali, and would a larger of acid, than the pure ſalt contains, if he had not forced off part of it by the heat of ignition to which he afterwards expoſed the ſalt.

IF Mr. Wenzel had not expreſsly averred that he proceeded exactly in making this experiment as he had done in examining the contents of tartar of vitriolate, I ſhould ſuſpect he had done no more than ſaturate the alkali, and thence inferred the proportion of the ſtrongeſt acid contained in the dry ſalt. For the quantity of this ſtrongeſt acid contained in the quantity of ſpirit of vitriol expended is almoſt exactly in the ſame proportion as he found it in forming tartar vitriolate. In that caſe he found 218,75 grs. of his ſpirit of vitriol to contain 69 of the ſtrongeſt acid, and in the preſent caſe he found 285,33 grs. of the ſame ſpirit of vitriol to contain 90. Now 218,75.69 : : 285,33.90. And this proportion could not be found unleſs the red heat was

equal

equal in both caſes, as Glauber's ſalt loſes part of its acid in ſuch heat.

Mr. Wiegleb avoided this ſource of error, and by that means approached nearer to the truth *. He found 100 grs. of mineral alkali, which had been dried by heating it to redneſs, to loſe 42 grs. of fixed air when ſaturated with vitriolic acid, and that the reſulting ſalt heated to ignition weighed 133 grs.; theſe, therefore, conſiſted of 58 of mere alkali, and 75 of the ſtrongeſt vitriolic acid, conſequently 100 parts pure alkali take 130 of the ſtrongeſt acid, and afford 230 of dry Glauber's ſalt. And elſewhere † he ſays that 100 parts cryſtallized Glauber ſalt loſe 50 by deſiccation. Then if 50 of the dry ſalt take 50 of water, 133 ſhould take 133, and form 266 of cryſtallized ſalt; and hence 100 parts of this ſalt ſhould contain 21,8 of alkali, 28,2 of the ſtrongeſt acid, and 50 of water.

Of Cubic Nitre.

I saturated 367 grs. of the ſame ſolution of mild mineral alkali with 147 grs. of ſpirit of nitre, whoſe ſpecific gravity was 1,2754, and which contained 45,7 per cent. ſtandard. The air loſt was 14 grs. and by adding 939 of water, its ſpecific gravity temperature 58°,5 was 1,0401, which by a teſt experiment denotes $\frac{1}{16,901}$ of ſalt. There was an exceſs of acid of about 2 grs.; the whole weight was 1439 grs. The quantity of ſalt was therefore $\frac{14{,}39}{16{,}901}$ = 85,142 grs.; the quantity of pure alkali was 50,05 — 14 = 36,05 grs.; the quantity of ſtandard acid was 66,7, the ſum of both = 102,75. But of this quantity only 85,142 entered into the combination of the ſalt, therefore the remaining 17,608 were mere water loſt by the ſtandard acid. And if 66,7 parts ſtandard loſe 17,6 parts water, in combining with mineral alkali, 100 ſhould loſe 26,38. And conſequently 73,62 parts of this ſtrong acid are equivalent to 100 of the nitrous ſtandard, or 100 of this ſtrong acid to 135,8 of the nitrous ſtandard.

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* 7 Nev. Entdeck, p. 16.

† 2 Handbuck, p. 92.

HENCE 36 parts alkali took up 49 of the ſtrongeſt acid, conſequently 100 parts pure alkali ſhould take up 136, equivalent to 171 ſtandard, and afford 271 parts cryſtallized cubic nitre.

SECONDLY. 100 parts cubic nitre contain 42,35 of alkali, and 57,65 of the ſtrongeſt nitrous acid, equivalent to 78,33 of ſtandard nearly.

MR. Bergman's determination varies conſiderably from the reſults of ſucceeding experimenters. By his ſtatement 100 parts cubic nitre contains 32 of alkali, 43 of acid, and 25 of water *. Hence 100 parts pure mineral alkali ſhould take up 134,4 of the ſtrongeſt nitrous acid, or 135,5, as he elſewhere ſtates it (which does not differ much from my account) and afford 312 of cubic nitre.

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* Scheffer Vorleſſung. p. 128.

Mr. Wenzel found 71,5 grs. pure mineral alkali ſaturated by 347 of his ſpirit of nitre, and that the reſulting ſalt after ignition weighed 190,75 grs.; ſince this quantity contained 71,5 of alkali, he concluded the remaining 119,25 to be the ſtrongeſt acid. Hence, firſt, 100 parts pure alkali take up 167 of the ſtrongeſt acid, and afford 267 of cubic nitre.

Secondly, 100 parts cubic nitre contain 37,5 nearly of alkali, and 62,5 of acid. He elſewhere ſays 240 grs. of cubic nitre cryſtallized loſe by ignition 9 grs. of water, which alters the proportion in ſome reſpect, for then 100 parts of the cryſtallized ſalt ſhould contain 36 of alkali, 60 of acid, and 4 of water. The error of this reſult evidently proceeds from the ſame deceptions that vitiated the experiment on Glauber's ſalt, the loſs which he imagined due to the eſcape of water proceeded from the volatilization of the acid.

Mr. Wiegleb's determination was far more juſt. He found that 153 grs. of cubic nitre contained 64 of alkali, and 89 of the ſtrongeſt acid; from whence it follows that 100 parts alkali take up 139 of the ſtrongeſt acid, and affords 239 of cubic nitre. Secondly, that 100 parts of this ſalt contain 41,83 of alkali, and 58,17 of the ſtrongeſt acid. It is remarkable that the nitrous acid not only exiſts in greater plenty, but is much more concentrated, in cubic than in priſmatic nitre.

Of Common Salt.

367 grs. of the ſame alkaline ſolution, containing 50,05 of mild marine alkali, were ſaturated by 129 grs. of ſpirit of ſalt, whoſe ſpecific gravity was 1,1355 with the loſs of 20 grs. of fixed air after ſome hours. On adding 26 grs. more of water, and 4 of pure common ſalt, the ſpecific gravity of the ſolution was 1,0814 in temperature 60°; which by a teſt experiment denoted $\frac{1}{8,33}$ of ſalt. The weight of the ſolution was 506 grs. and conſequently the quantity of ſalt was $\frac{506}{8,33} = 60,74$ grs.; but as 4 grs. of ſalt were added, the weight of the regenerated ſalt ſingly was 56,74 grs.; the acid employed contained 34 per cent. ſtandard, conſequently 129 grs. of it contained 43,86 ſtandard. The quantity of mere alkali was 30,05 grs. the ſum of both $=73,91$ grs.; yet only 56,74 grs. of ſalt were formed, conſequently the difference, or $73,91-56,74=17,17$ grs. were mere water rejected from the ſtandard acid. And if 43,86 ſtandard loſe 17,17 on uniting to mineral alkali, 100 parts ſtandard ſhould loſe 39,14, and conſequently the remainder, viz. 60,86 party of this ſtrong acid, are equivalent to 100 parts ſtandard, or to 48,4 of the ſtrongeſt, ſuch as is found in ſalt of Sylvius. Hence, firſt, 100 parts pure marine alkali take up 88,81 of this ſtrong acid, equivalent to 145,92 of ſtandard, and ſhould produce 188,81 of ſalt. Secondly, 100 parts common ſalt contain nearly 53 of alkali, and 47 of acid ſtronger than ſtandard in the proportion above mentioned.

In this account no notice is taken of the water of cryſtallization, for in fact common ſalt does not appear to contain any; that which is got rid of by heat ſeems to me to be merely accidental. Mr. Wild, who has attended ſo ſucceſsfully to every thing relating to this ſalt, affirms that 911 grs. of it loſe but 7,1 by decrepitation *. Mr. Storr found it to loſe none in any heat below 590°. As common ſalt does not eſcape in any conſiderable degree during the evaporation of its ſolution, and retains its acid in the ſtrongeſt heat, the reſults of Meſſrs. Wenzel and Wiegleb, and particularly that of the latter, agree very nearly with the foregoing.

According to Mr. Wenzel 71,5 of pure mineral alkali were ſaturated by 266,5 of his ſpirit of ſalt, and the reſiduum after ſubtracting 1 gr. of earth and expoſure to ignition weighed 131,5 grs.; this quantity, therefore, contained 71,5 grs. of alkali, and 60 of the ſtrongeſt acid. Hence 100 grs. pure mineral alkali ſhould take up nearly 84 of the ſtrongeſt acid, and produce 184 of common ſalt; and ſecondly, 100 parts common ſalt contain 54,37 of alkali, and 45,63 of the ſtrongeſt acid.

According to Mr. Weigleb 105 grs. of common ſalt contain 56 of alkali, and 49 of the ſtrongeſt acid. Hence 100 parts contain 53,5 of alkali, and 46,5 of acid. Hence 100 parts pure alkali

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* Beytrage zu Salkzunde, p. 94.

alkali ſhould take up 87,5 of the ſtrongeſt marine acid, and afford 187,5 of common ſalt, which is nearly my concluſion.

Mr. Bergman's proportion deviates ſo widely from theſe reſults, that I can in no way account for it. He attributes to 100 parts of this ſalt, 42 of alkali, 52 of acid, and 6 of water.

Of Ammoniacal Salts.

Before I proceed to the analyſis of thoſe formed by the mineral acids, it will be neceſſary to examine the compoſition of aerated volatile alkali, which was the ſubject of my experiments.

The proportion of ingredients aſſigned to this ſalt by Mr. Bergman is 12 of water, 45 of fixed air, and 43 of pure alkali. How he has diſcovered this proportion he no where explains, nor do I know any other method of exploring it with accuracy than by having recourſe to Dr. Prieſtley's experiments, vol. ii. of his new edition*.

By theſe it appears that 2 meaſures of alkaline air are ſaturated and reduced to a concrete form by 1 meaſure of fixed air very nearly. Now 100 cubic inches of alkaline air I have found to weigh 18,16 grs.; and 100 cubic inches of fixed air 46,5.

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* Page 386.

Let us ſuppoſe a meaſure to conſiſt of 100 cubic inches, then 2 meaſures of alkaline air will weigh 36,32 grs.; theſe take up 46,5 of fixed air, and the concrete ſalt thus formed will weigh 82,82 grs.; then if 82,82 parts of concrete volatile alkali contain 36,32 of pure alkali as free from water as it can be had, 100 parts of this concrete ſalt ſhould contain 44 nearly of ſuch alkali, and 56 of fixed air. And here the quantities of theſe two ingredients muſt always be proportional, as the alkali cannot be reduced to a concrete form without a due proportion of the aerial acid, nor the acid without the due quantity of alkali. Therefore knowing the quantity of fixed air in any given weight of this dry ſalt, we may determine the quantity of alkali by the above analogy, and this being found, the qnantity of water exceeding that exiſting in alkaline and fixed airs muſt alſo be known, it being the remainder of the given weight of the ſalt.

Of Vitriolic Ammoniac.

100 grs. of mild concrete volatile alkali, formed by ſublimation, and diſſolved in 1000 of water, were ſaturated by 132 of vitriolic acid, whoſe ſpecific gravity was 1,5654, which contained 61 per cent. ſtandard. The loſs of air was 45 grs. and hence the quantity of mere alkali was 35,35 grs. the ſpecific gravity of the ſolution in temperature 59° was 1,0627.

THE ſpecific gravity of a ſolution of 100 grs. of cryſtallized vitriolic ammoniac in 821 grs. of water and temperature 59° was alſo 1,0627. Hence the proportion of ſalt in both ſolutions was equal, viz. $\frac{1}{9,21}$ of the whole; the weight of the ſolution containing the regenerated ſalt was 1187 grs. then the quantity of ſalt contained in it was $\frac{1187}{9,21} = 128,881$ grs. The quantity of pure alkali was 35,35 grs.; the quantity of ſtandard 80,52 grs.; the ſum of both = 115,87; then the remainder of the 128,881 grs. of ſalt muſt have been water, amounting to 13,011 grs.

Hence 100 parts of pure volatile alkali take up 227,7 of the vitriolic ſtandard, and, including water, ſhould afford 364,6 of cryſtallized vitriolic ammoniac. Secondly, 100 parts cryſtallized vitriolic ammoniac contain 27,42 of mere alkali, 62,47 of ſtandard acid, and 10,11 of water.

Mr. Wenzel's method of inveſtigating the proportion of ingredients in ammoniacal ſalt is very ingenious, but obſcurely related, and does not ſeem to have ſecured even his own confidence.

Into half an ounce of *his* ſpirit of vitriol * he gradually dropped 160 grs. of dry concrete volatile alkali, and found the weight loſt amount to 86 grs. and hence he concluded this quantity of alkali to contain 86 grs. of fixed air. This concluſion

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* See an eſtimation of its ſtrength in the article *tartar vitriolate*.

cluſion every one who has made the experiment muſt know to be erroneous, for the ſmell of the alkali evidently indicates that it eſcapes along with the fixed air, when it is not previouſly much diluted.

Again, into another half ounce of his ſpirit of vitriol he dropped 336 grs. of common ſpirit of ſal ammoniac, and found the loſs of air to be but 38 grs.; hence he concluded the quantity of real alkali to be proportionably ſmaller than in his firſt experiment. Having attained the point of ſaturation, he gently evaporated the ſolution and expoſed the newly formed ſalt to a heat of 212° for four hours, and then found it to weigh 129 grs.; now as his ſpirit of vitriol contained 75,75 grs. of the ſtrongeſt vitriolic acid, he ſuppoſed the ſalt thus formed to contain that quantity of the ſtrongeſt acid, and this ſuppoſition is juſt; but he further ſuppoſes that all the water contained both in the acid and in the alkali was expelled by the heat of 212°, which cannot be credited; and thence infers that the remainder of the 129 grs. was pure alkali, viz. 53,25 grs. a concluſion which the premiſes do not warrant. It is therefore uſeleſs to examine his ſubſequent deductions: by my computation the quantity of vitriolic ammoniac that ſhould reſult from Mr. Wenzel's experiment is 135 grs. for 240 grs. of his ſpirit of vitriolic contain 84,72 of my ſtandard; and ſince 62,47 of ſtandard go into the compoſition of 100 parts vitriolic ammoniac, 84,72 ſhould enter in that of 135 grs. of that ſalt; 6 grs. were therefore probably loſt during the evaporation of Mr. Wenzel's ſalt, or eſcaped with the fixed air.

Neither Meſſrs. Bergman nor Wiegleb have treated of this ſalt; but here Dr. Prieſtley again ſteps into our aſſiſtance; he found that two meaſures of alkaline air were exactly ſaturated by one of vitriolic air; hence it follows that 36,32 grs. of pure alkali take up 70,215 of the ſtrongeſt volatile vitriolic acid, and conſequently 100 of volatile alkali take 193. In uniting to the volatile alkali it depoſits part of its ſulphur.

Of Nitrous Ammoniac.

100 grs. of mild concrete volatile alkali diſſolved in 1000 of water were ſaturated by 446 grs. of ſpirit of nitre, whoſe ſpecific gravity was 1,1418, which contained 24,8 of ſtandard. The loſs of air was 43 grs. which indicates 33,8 grs. of pure alkali; the ſpecific gravity of the ſolution was 1,0401, which by a teſt experiment indicates $\frac{1}{10,7}$ of cryſtallized ſalt. The weight of the ſolution was 1503 grs. then the quantity of ſalt was $\frac{1503}{10,7}=140,467$ grs. which is ſomewhat leſs than the quantity of pure alkali and ſtandard employed, for the quantity of pure alkali is 33,8 grs. and that of ſtandard in 446 grs. of the nitrous acid employed, is 110,608, and the ſum of both =144,408, which differs by 3,941 grs. from the ſalt formed; this quantity therefore muſt have been mere water rejected from the ſtandard acid; and if 110,608 grs. ſtandard loſe 3,941 in uniting to volatile alkalies, 100 parts ſtandard ſhould loſe about 3,5, and

hence 96,5 parts of this ſtrong acid are equivalent to 100 of ſtandard.

Hence it alſo follows that 100 parts pure volatile alkali take up 316 of this ſtrong nitrous acid, equivalent to 327,4 of ſtandard, and ſhould afford 416 of cryſtallized nitrous ammoniac.

2dly, 100 parts nitrous ammoniac contain 24 of alkali and 76 of the ſtrongeſt nitrous acid, equivalent to 78,75 of ſtandard.

Yet I muſt obſerve, that as the nitrous ammoniac employed in the teſt ſolution was not purified by a ſecond cryſtallization, and contained ſome exceſs of acid, there probably is a ſlight inaccuracy in this experiment; but I form no doubt but this ſalt contains above 70 per cent. of the ſtrongeſt acid, and at moſt 28 of alkali.

According to Mr. Bergman, 100 parts pure volatile alkali take up 132 of the ſtrongeſt nitrous acid*; but this contradicts the rule he himſelf lays down, that baſes that have a weaker attraction for a given acid, take up more of that acid than an equal quantity of a baſis that has a ſtronger attraction to it can take up. Now by his own experiments, 100 parts pure mineral alkali take up 135,5 of the ſtrongeſt nitrous acid, therefore 100 parts pure volatile alkali ſhould take up much more.

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* Scheff. Vorleſs. p. 129.

It is evident he was led into this miſtake by not knowing the proportion of water that enters into mild concrete volatile alkali.

Mr. Wenzel aſſigns to this ſalt a much larger proportion of acid, though even his appears to me too low; by his computation 41 parts pure volatile alkali, ſaturated with nitrous acid, afford 127 of nitrous ammoniac, dried by four hours expoſure to a heat of 212°; but it muſt be remarked that its decompoſition begins at a much lower heat, as Mr. Cornette has obſerved*, and it ſublimes at the heat of 234°. However, from this experiment it follows that 100 parts pure volatile alkali take 205 of the ſtrongeſt nitrous acid, and afford 305 of nitrous ammoniac.

I made this experiment according to my antient method, with the following reſult: I ſaturated 200 grs. of mild concrete volatile alkali with ſpirit of nitre, whoſe ſpecific gravity was 1,1538, 984 grs. of it were requiſite, the loſs of air was 100 grs. the ſolution, gently evaporated in a heat of 70° or at moſt 80°, afforded a maſs of ſalt moſtly cryſtallized, which weighed 296 grs.; here the quantity of pure alkali, according to the rule of proportion above laid down, was 78,6; and if 100 parts pure volatile alkali afforded 416 of nitrous ammoniac, as I have above determined, 78,6 ſhould produce 327 nearly, yet I found but 296, therefore 31 were loſt, probably during the evaporation.

Of

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* Mem. Paris 1783, p. 746.

Of Common Sal Ammoniac.

100 grs. of aerated volatile alkali diſſolved in 1000 of water, required for their ſaturation 246 of ſpirit of ſalt, whoſe ſpecific gravity being 1,1355, contained by my table 34 grs. ſtandard per cent. and the quantity employed held 83,64 ſtandard; the loſs of air was 43 grs. and conſequently the quantity of pure alkali 33,8 grs. the ſpecific gravity of the ſaturate ſolution 1,0269, the whole weight was 1303, which by a teſt experiment indicated its ſaline contents to be $\frac{1}{10,67}$, now $\frac{1303}{10,67}=122,118$ grs.

Now the ſum of pure alkali and ſtandard$=117,44$; the difference therefore of theſe two quantities, viz. 4,67, muſt have been water united to the ſtandard acid.

HENCE 100 parts pure alkali take up 247,1 ſtandard, and ſhould produce 361 of cryſtallized ammoniac.

2dly, 100 parts ſal ammoniac then contain 27,62 of alkali, 68,49 of ſtandard, and 3,89 water; yet when I made this experiment after the antient method I obtained a much ſmaller proportion of ſalt.

HAVING diſſolved 200 grs. of aerated volatile alkali in 1800 of water, and ſaturated it with the ſame marine acid, of which it required 486 grs. with the loſs of 100 grs. of fixed air, the evaporated ſolution afforded only 224 grs. Now the quantity of pure alkali by my computation being 78,6 grs. ſhould afford by the above obſervation 284,5 grs. therefore 60,5 were loſt.

Mr. Wenzel attributes to 110 parts of ſal ammoniac 56 of alkali and 54 of acid, but it is plain he was deceived both by the miſcalculation of the quantity of real alkali in his aerated alkali, and by the volatilization of part of the ſalt during the evaporation of the ſaturated ſolution.

Of the Relation of the Nitrous Acid to Calcareous Earth.

To 400 grs. of ſpirit of nitre, whoſe ſpecific gravity was 1,2754, I gradually added in temperature 58° ſome finely powdered white ſtatuary marble, whoſe grain in the fracture reſembled that of ſugar; of this 136 completely ſaturated the acid in two days, the loſs of air was 61 grs. or nearly 45 per cent. This proportion of air is much greater than that which I found ſome years ago, but at that time I diſſolved without applying heat, the marble in dilute vitriolic acid, which does not eaſily penetrate the whole maſs, as the ſelenitic cruſt formed during the firſt acceſs of the acid protects the remainder from its action.

This acid contains 45,7 per cent. ſtandard, conſequently the 400 grs. employed contain 182,8 of ſtandard; and ſince 182,8 parts ſtandard took up 136 of this marble, 100 parts ſtandard ſhould take up 74,4. An opportunity was hereby afforded me of comparing different parts of my table of the proportion of ſtandard in nitrous acid of different ſpecific gravities with the experiments of Mr. Cavendiſh.

THIS accurate philoſopher found that ſpirit of nitre, whoſe ſpecific gravity in temperature 58° is 1,4923, diſſolves $\frac{1}{1,42}$ of its weight of marble*. Hence 100 parts of it ſhould diſſolve 70,42 of marble. Now by my table 100 parts of this acid contain 91,7 parts ſtandard, and ſince 100 parts ſtandard diſſolve 74,4 of marble, 91,7 parts ſhould diſſolve 68,22; and in this manner I have compared the remainder of his reſults.

Specific Gravity of 100 Parts nitrous Acid.	Marble diſſolved by Mr. Cavendiſh.	Marble diſſolved by my Table.
1,4923	70,42	68,22
1,4371	58,2	57,28
1,404	53,00	52,45
1,4033	53,00	52,3

THESE differences are very ſmall, and may proceed partly from the defects of the table and partly from the difference of the marbles employed; that his marble was ſomewhat different from mine appears from this, that his gave but 40,7 per cent. of fixed air.

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* Phil. Tranſ. 1783, p. 325, and 1786, p. 245.

It is difficult to aſcertain the preciſe quantity of pure calcareous earth in marble or any calcareous ſtone, by reaſon of the quantity of water they are alſo ſaid to contain. The marble I examined contained 3 per cent. of a mixture of argil and minute cryſtals, which rendered the ſolution turbid when ſomewhat more than half ſaturate; but I collected this proportion from a ſolution of the ſame marble in ſpirit of ſalt. If marble contained no water the quantity of calcareous earth would thence be eaſily had, as the quantity of air being 45 grs. that of the earth ſhould be 55, and deducting 3 for foreign earths, the pure calcareous would be 52. Mr. Coudray is the only perſon I can recollect who found water in white marble[*], but his experiment was defective. Dr. Watſon could detect none by diſtillation even in ſpar[†]. I diſtilled a ſolution of marble in nitrous acid to dryneſs, and expelled all the acid, for the earth was converted into lime; I was however diſappointed, for I could not collect the whole of it, as part ſtuck to the retort. But Mr. D'Arcet having calcined a piece of white marble of Carrara in the ſtrongeſt porcelain heat, in which he found it to loſe no more than $\frac{4}{9}$ of its weight, exactly the ſame as by ſolution in acids, ſeems to me to have decidedly proved that it contains no water[‡]. Then if 100 parts of this marble contain 52 of pure lime, 74 parts will contain 38,68, and theſe take up 100 parts of the nitrous ſtandard, then 100 parts lime take 258,5 of this ſtandard.

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[*] 5 Roziers, p. 280.

[†] 2 Watſon, p. 252.

[‡] 22 Roziers, p. 23.

Mr. Lavoiſier, in diſcuſſing the merits of that memorable controverſy which his experiments have for ever cloſed, diſſolved a large quantity of chalk in ſpirit of nitre, whoſe ſpecific gravity was 1,2989, and found that 1153 grs. Troy of chalk contained 606,47 of earth, which required 2835 of that ſpirit of nitre for their ſolution. Now 100 parts of this ſpirit of nitre contain by my table 49,6 of ſtandard, and conſequently the above quantity contains 1406,16. Now if 606,47 of this earth take up 1406,16 of ſtandard, 100 of the earth ſhould take up 232, which appears leſs than my eſtimation; but it muſt be remembered that I deducted 3 grs. per cent. for foreign earth mixed with the marble, and it is certain that chalk is more impure; then if it contains leſs of calcareous earth it muſt take proportionably leſs of ſtandard; the proportion of foreign earth may even thus be detected. By this teſt it would appear that the chalk uſed by Mr. Lavoiſier contained but 46,5 per cent. or 0,465 of its weight of earth *really* calcareous.

Mr. Wenzel's experiments on calcareous earths are ſo combined with his opinion of the preſence of the *acidum pingue* or *cauſticum*, that no clear concluſion can be deduced from them.

Of the Relation of the Muriatic Acid to Calcareous Earths.

158 grs. of powdered marble were taken up by and ſaturated 402 grs. of ſpirit of ſalt, whoſe ſpecific gravity was 1,1355. This acid contained 0,34 of its weight of ſtandard, and con-

ſequently the quantity employed contained 136,68; whence it follows that 100 parts marble ſaturate 86,5 of the marine ſtandard. To obtain a perfect ſolution a heat of 160° was employed towards the end.

From the proportion of pure calcareous earth already mentioned, it follows that 158 grs. of this marble contained but 82,26 of that pure earth. Then 82,26 parts lime take 86,5 of ſtandard, conſequently 100 parts lime ſhould take 104,72.

According to Mr. Wenzel, 100 parts lime take 103,6 of the ſtrongeſt marine acid, but the circumſtances were very different from thoſe in which he firſt collected its degree of concentration.

Of Vitriolic Selenite.

To 225 grs. of oil of vitriol, whoſe ſpecific gravity was 1,5654, I added 225 grs. of water, and of this mixture I took 439 grs. and gradually added to it at different times 152 grs. of finely powdered white marble. It was committed to a gentle ſand heat, more water was added from time to time; the ſaturation was obtained at the end of ten days.

The quantity of acid employed contained 134 grs. ſtandard; hence 100 grs. ſtandard take up 113,4 of marble, and 100 parts marble require 88,17 of the vitriolic ſtandard; but 100 parts of this marble contain 52 of lime, then 100 parts lime take up 169,55 of the vitriolic ſtandard.

The ſelenite thus obtained being evaporated to dryneſs in a ſand heat not exceeding 170°, was of compact, but not hard conſiſtence, felt mealy, and of a reddiſh brown colour at the ſurface; it weighed 242,25 grs.; of this weight 79 were pure calcareous earth, 134 vitriolic ſtandard, 5 of foreign earth, and the remainder, viz. 24, were water. Hence 100 grs. ſelenite in this form contain 32,9 of pure earth, 55 of ſtandard acid, and 12,1 of water; but this determination is not accurate, as the argil muſt have taken part of the acid.

Mr. Cavendiſh having in many inſtances ſought the relation betwixt the ſpecific gravity of oil of vitriol and the quantity of marble it can diſſolve, it will be proper to compare his reſults with my table *.

100 Parts Oil Vitriol.	Marble diſſolved by Mr. Cavendiſh.	Marble diſſolved by my Table.
1,8437	98	99,9
1,5596	65,4	68,
1,780	84,8	93,6

With

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* Philoſop. Tranſactions, 1786, p. 245, and 1788, p. 181.

WITH reſpect to this laſt the difference ſeems conſiderable, but the reaſon is that Mr. Cavendiſh made the experiment from which he inferred the ſtrength of this acid with vitriol of lead, though he expreſſed it by reference to the quantity of marble he deemed it would diſſolve.

I ALSO tried to find the quantity of ſtandard acid the diſſolved marble would require to precipitate it from its ſolutions in the muriatic and nitrous acids, and for this purpoſe: To the ſolution of 158 grs. of marble in the marine acid above-mentioned I gradually added after dilution oil of vitriol 1,5654. This operation is very tedious, as the vitriolic ſelenite is in great meaſure ſoluble in the marine acid, or at leaſt in the ſolution of marine ſelenite, ſo that frequent evaporation and repeated waſhings were requiſite; however it appeared to me that 253,5 grs. of the acid were requiſite to precipitate the whole of the diſſolved calx. Now 253,5 grs. of this acid contain 154,33 of ſtandard, conſequently 100 grs. marble require for their precipitation from the muriatic acid 102 grs. of ſtandard vitriolic acid, or rather computing the marble to contain 52 per cent. lime, 100 grs. pure calcareous earth require for their precipitation from the marine acid 124,15 of vitriolic ſtandard. Perhaps the difference between the quantity requiſite in this caſe and that found requiſite for ſolution may ariſe from this, that the argillaceous earth remains untouched in this caſe, as no more acid is added when the decompoſition ceaſes to be viſible, whereas a ſufficiency to diſſolve and ſaturate it is added in the former caſe.

To obtain ſtill more ſatisfaction I alſo precipitated the nitrous ſolution of marble above mentioned by a ſolution of tartar vitriolate. This ſolution contained 135 grs. of marble; the quantity of tartar vitriolate neceſſary to precipitate it was 174 grs. Now 135 grs. marble contain 70,2 of pure calcareous earth, and 174 grs. tartar vitriolate contain 87 ſtandard vitriolic acid; whence it follows, that if 70,2 require 87, 100 will require 123,93 nearly, the ſame as when the uncombined acid was uſed; this experiment is therefore a proof of the accuracy of ſome of the former determinations.

The ſelenite thus obtained being ſo far dried as to retain its ſilky gloſs, weighed 205,25 grs.; hence 100 parts of it ſhould contain 34 of earth, 43 of ſtandard acid, and 23 of water. This determination, which varies conſiderably from the former, appears to be more exact, becauſe in diſſolving marble part of the acid is neceſſarily taken up by the argillaceous earth contained in it, whereas here nothing is brought into the account but the acid taken up by the earth precipitated, that is, by the calcareous earth ſingly. The proportion of water is alſo different, becauſe the deſiccation was not puſhed ſo far.

According to Mr. Bergman, 100 parts gypſum contain 32 of earth, 46 of acid and 22 of water. If he means acid of the ſame ſtrength as that contained in tartar vitriolate, (which he muſt mean, or the expreſſion is ambiguous) he is certainly miſtaken, for then 115 parts tartar vitriolate ſhould contain the ſame quantity of acid as 100 parts gypſum, whereas by the laſt experiment it appears that 84 parts tartar vitriolate are in that reſpect equal to 100 of gypſum.

Of Epſom Salt.

It is generally agreed that common aerated magneſia loſes above $\frac{1}{2}$ its weight by calcination in a red heat, which expels all the water and fixed air that inheres in it. Dr. Black, whoſe fortunate inquiries concerning the nature of this earth, laid the foundation of the greater part of the modern improvements in chemiſtry, found it to loſe about 51 per cent. Mr. Butini of Geneva 59 per cent. Mr. Wenzel 58 per cent. Mr. Bilhabar 65 per cent. and Mr. Bergman 55 per cent. As magneſia loſes a ſmall part of its earth when calcined in an open veſſel, as was diſcovered by Mr. Tingry, perhaps we may acquieſce in Mr. Bergman's determination, as approaching to a mean among thoſe of other chemiſts.

A solution of 100 grs. cryſtallized Epſom in 926 of water had its ſpecific gravity in the temperature of 56° = 1,0448; the weight of the ſalt was therefore $\frac{1}{10,26}$ of the whole weight of the ſolution.

50 grs. of oil vitriol, whoſe ſpecific gravity was 1,5654, and which by the table contained 0,61 of its weight of ſtandard, were diluted with 599 of water. This dilute acid was ſaturated by 35 grs. of common magneſia, and when 278 grs. more of

water were added, the ſpecific gravity of the ſolution, temperature 56°, was 1,0448, its weight was 949 grs. then $\frac{1}{10,26}$ of this weight was regenerated Epſom=92,494 grs. of ſalt; the quantity of mere earth was $35 \times ,45 = 15,75$ grs. that of ſtandard was 30,5, and the remainder=53,75 muſt have been water.

Hence 1°—100 parts cryſtallized Epſom contain 17 of earth, 32,97 of ſtandard acid; or in round numbers, 17 of earth, 33 ſtandard acid and 50 of water.

Hence 2do—100 parts pure magneſia take up 194 of vitriolic ſtandard, and ſhould afford 589 of cryſtallized Epſom.

Mr. Bergman found 100 parts Epſom to conſiſt of 19 of earth, 33 of the ſtrongeſt acid and 48 of water. Whence by him 100 parts of this earth ſhould take up 173,7 nearly of the ſtrongeſt acid, and produce 526 parts of cryſtallized Epſom.

Here the difference between our reſults is apparently but ſmall, reſpecting only the proportions of earth and water, he attributing two parts leſs both of earth and water; but though our *expreſſion* relatively to the proportion of acid is the ſame, yet our *meaning* is very different; for he means 33 parts of an acid of the ſame ſtrength as that found in tartar vitriolate, and I mean only ſtandard vitriolic acid, which is much weaker, as 100 parts Epſom contain but 29 parts of an acid of the ſame concentration as that found in tartar vitriolate. This helps to explain a circumſtance which appeared very ſingular to Mr.

Bergman: In decompoſing Epſom ſalt, he obſerved that although 45 parts of cauſtic vegetable alkali were neceſſary to effect the decompoſition of 100 parts of Epſom, only 30 parts tartar vitriolate could be obtained. Nevertheleſs, according to his own determination of the compoſitions of Epſom ſalt and tartar vitriolate, 82 grs. of tartar vitriolate ſhould have been formed, for by his account 40 parts of the ſtrongeſt vitriolic acid ſhould, if there be a ſufficiency of vegetable alkali, form 100 of tartar vitriolate, conſequently 33 parts of that acid, which exiſt in 100 parts of Epſom ſalt, meeting with more alkali than they require, ſhould produce 82 of tartar vitriolate, and yet only 30 of this ſalt can be recovered. This Mr. Bergman attributes to an exceſs of alkali which prevents the remainder of the tartar vitriolate (viz. 52 parts) from cryſtallizing; yet by his own account this exceſs amounts only to 2 grs. for ſince by him 40 parts of the acid take up 52 of alkali, 33 parts of the ſame acid ſhould take up 42,9, and the whole quantity of alkali is but 45. By my determination of the proportion of ingredients in theſe ſalts this phænomenon is more intelligible, 100 parts Epſom contain 33 of ſtandard vitriolic acid, which are equivalent to 29 of ſuch acid as exiſts in tartar vitriolate, and conſequently ſhould produce only 64,4 parts of tartar vitriolate, but 64 of tartar vitriolate contain but 35 of mere alkali, conſequently 10 parts uncombined alkali remain, which may poſſibly embarraſs the cryſtallization of 34 of tartar vitriolate, if ſo much more be formed, which is rather doubtful, as 45 parts of cauſtic alkali may not furniſh ſuch an exceſs as may be requiſite to decompoſe the laſt portions of Epſom.

THIS experiment ſeems a full proof of the inaccuracy of Mr. Bergman's determination of the proportion of ingredients in theſe two ſalts, Epſom and tartar vitriolate.

MR. Wenzel informs us that 240 grs. of his ſpirit of vitriol were ſaturated by 100 of aerated magneſia, and that this ſolution furniſhed him 247 of cryſtallized Epſom. 240 grs. of this magneſia he employed loſt in a long continued red heat 140 grs. Hence he concludes the proportion in half an ounce of cryſtallized Epſom to be 40,5 grs. of pure earth, 73,6 of the ſtrongeſt acid and 126 of water, whence 100 parts Epſom ſhould contain 16,87 of earth, 30,66 of acid and 52 of water. This reſult does not differ much from mine, and we have already ſeen that 31,5 of his ſtrong acid are equivalent to 35,3 of ſtandard, conſequently 30,66 are equal to 34,3 of ſtandard, and the remainder, viz. 51,13, is water.

Of the Relation of the Nitrous Acid to Magneſia.

I FOUND that 100 parts pure magneſia take up 286 of the nitrous ſtandard.

MR. Wenzel found that 77 grs. of aerated magneſia ſaturated 240 of his nitrous acid, which contained 82,5 of the ſtrongeſt acid. Whence he concludes, that as this earth contains 0,417 of its weight of mere earth, 100 parts pure earth take up 257 of his ſtrongeſt acid; but if we ſuppoſe the aerated magneſia to contain 0,45 of its weight of pure earth, then 34,65 parts of it took up 82,5 of his ſtrongeſt acid, and 100 ſhould take up 238, equivalent to 264 of my ſtandard.

Of the Relation of Marine Acid to Magneſia.

By my experiments 100 parts pure magneſia take up 215,8 of the muriatic ſtandard. According to Mr. Wenzel, 106 grs. of aerated magneſia ſaturated 240 of *his* ſpirit of ſalt, which contained 54 grs. of his ſtrongeſt acid, equivalent to 112 of ſtandard. But if his magneſia contained 45 of its weight of pure earth, then 106 contained but 47,7, and in that caſe 100 parts pure magneſia ſhould take up 234 of the marine ſtandard.

Of Allum.

The proportion of ingredients in this ſalt I endeavoured to diſcover by decompoſing it.

1°. To aſcertain the proportion of earth, I diſſolved 480 grs. of this ſalt in 2880 of water, and precipitated the earth by a ſolution of mild volatile alkali, both being heated; the precipitate after edulcoration was heated to 465° it weighed 141 grs. Hence 100 parts allum contain 29,37 of earth in that ſtate of dryneſs which the heat abovementioned can produce.

2do. To find the proportion of water of cryſtallization, I diſtilled 480 grs. of allum in a heat of 465° and obtained 200 grs.

of water perfectly inſipid. Hence it would follow that 100 parts allum contain 41,66 of water of cryſtallization; but having calcined 100 grs. of allum in a ſand heat where the evaporation was freer, I found the loſs of weight to be 45,5, but then the laſt drop was acid. Hence I conclude the water of cryſtallization to amount to 44 per cent.

THE reſiduum of 100 parts cryſtallized allum, amounting to 26,63 grs muſt therefore have been mere acid, or acid ſtill retaining a quantity of water not ſeparable by a heat of 465°. To reſolve this doubt I made a ſolution of 100 grs. cryſtallized allum in 1600 of water, heated it to 200°, and gradually added to it a ſolution of mild vegetable alkali, which contained $\frac{1}{4,186}$ of its weight of *mere* alkali, being the ſame I uſed in forming tartar vitriolate, &c. I continued adding this as long as any effervеſcence appeared, making the mixture to boil; the quantity employed and neceſſary to ſaturate the acid was 90 grs. that is $\frac{90}{4,186}=21,5$ grs. of mere alkali. Now we have already ſeen that 100 parts mere vegetable alkali take up 92 of the vitriolic ſtandard, therefore 21,5 grs. of pure vegetable alkali take up

19,78

When allum is decompoſed by aerated alkalies without boiling, (and a fortiori in cold) a ſmall part only of the acid is ſeparated, the greater part of the alkali unites without loſing its air to the precipitate, forming a ſalt compoſed of aerated alkali, earth and vitriolic acid; when the earth is properly ſeparated it falls in a granular and not in a flaky ſtate.

19,78 of this ſtandard; this therefore is the quantity of ſtandard in 100 parts of the cryſtallized allum. The remainder therefore of the 26,63 parts reſiduum juſt mentioned, viz. 6,85 grs. are mere water retained by the ſtandard acid.

Hence the proportion of ingredients in 100 parts cryſtallized allum is,

Earth - - - -	29,37 parts.
Standard acid - - -	19,78
Water retained by the ſtandard acid -	6,85
Water of cryſtallization - -	44,00
	100,00

or in other words, 100 parts allum contain 29,37 of earth, 26,63 of acid, whoſe ſpecific gravity is 1,7509, and 44 of water of cryſtallization.

100 parts burnt or calcined allum contain about 52,3 of earth, 35,2 of ſtandard acid, and 12,5 of water.

According to Mr. Bergman, 100 parts cryſtallized allum contain 18 of earth, 38 of acid, and 44 of water. It is probable he heated the earth to a very high degree, for in a red heat it retains the ſame weight as at 460°, but as to the quantity of acid it is certainly inferior to the weight he aſſigns, if Mr. Wenzel's and my own can be relied on.

Mr. Wenzel decompoſed 480 grs. of allum by the nitrous ſolution of lead, through a double affinity. The precipitate which conſiſted of vitriol of lead, well waſhed in warm water and dried in a red heat, weighed 144 grs. and this he ſuppoſed contained all the acid in the ounce of allum. Now by a former experiment he found that 240 grs. of vitriol of lead contain 72,57 of the ſtrongeſt vitriolic acid, that is 30,23 per cent. and hence 144 grs. of this ſalt contain 43,54. This then he concludes to be the quantity contained in an ounce of allum; at this rate 100 parts allum contain only 9,07 of the ſtrongeſt acid. This enormous difference evidently proceeds from the defective method employed by Mr. Wenzel, for 1° if the ſolution of allum were evaporated to dryneſs, the nitrous allum was neceſſarily mixed with the vitriol of lead, and in waſhing it away much of the vitriol of lead muſt have been carried off, and if it were not evaporated to dryneſs part of the vitriol of lead remained in the ſolution. However, to find a more ſecure method of uſing this uſeful precipitant, which operates much quicker than any Barytic ſolution, I repeated this experiment.

For this purpoſe I diſſolved 30 grs. of lead in 400 grs. of nitrous acid, 1,1477 diluted with 200 of water in a heat of 90°, 7 grs. were loſt by evaporation or air, the remaining 623 grs. contained 30 of lead.

I then diſſolved 100 grs. of allum in 1600 of pure water, and placing it in a ſand heat gradually added the ſolution of lead, as the precipitate ſettled and the liquor evaporated; when the whole was reduced to half a ſpoonful I found that 235 grs. of the ſolution of lead had been employed; the reſiduum evidently contained vitriol of lead, as it appeared to form a pellicle on the ſurface of the liquor.

Now ſince 623 grs. of the ſolution of lead contained 30 of lead, 235 grs. of this ſolution muſt have contained 11,31. And ſince in vitriol of lead 70 parts lead indicate the preſence of 30 of the ſtrongeſt vitriolic acid, (in which ſtatement both Meſſrs. Bergman and Wenzel agree), the preſence of 11,31 grs. of lead indicate the preſence of 4,84 of this ſtrongeſt acid. We have already ſeen that the ſtrongeſt vitriolic acid is to the ſtandard acid as 82 to 92, then 4,84 grs. of this acid are equivalent to 5,4 of ſtandard, which is ſtill far below the truth.

As to the quantity of earth, Mr. Wenzel found by precipitating the earth contained in an ounce of allum by a fixed alkali, that it amounted when dry to 140 grs. that is 30 per cent. as I had done. But in a ſtrong heat continued for two hours the whole was reduced to 90 grs.; then 100 parts allum ſhould contain nearly 19 per cent. of earth. Then the 29,78 grs which exiſted in the degree of deſiccation I employed might be reduced to 19 For 140. 90::29,78.19 nearly*.

Of

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* From the proportions here rigorouſly determined, it appears that ſome of the poſitions in my late paper on the alkalies uſed in bleaching are not exact.

Of Vitriol of Iron.

250 grs. of cryſtallized vitriol of iron expoſed to a ſand heat of 420° became of a dirty white colour, and loſt 98 grs. of its weight, that is 39 per cent.

480 grs. of the cryſtallized vitriol of iron diſtilled in a ſand heat of 460° became grey and loſt 191 grs. of water ſlightly acid, that is 40 per cent.

Hence I conclude that 100 parts vitriol of iron contain 39 of water of cryſtallization, the acidity indicates about 1 gr. of acid.

I then diſſolved 100 grs. of the cryſtallized ſalt in 3 ounces of water, and gradually added to it the teſt alkali, the ſame I uſed in the decompoſition of allum. In the temperature of 60° there was no effervescence, though a greyiſh precipitate appeared; but when the ſolution felt a heat of 120° a ſlight quantity of air was diſengaged, which increaſed as the heat approached to that of boiling, ſo that here alſo a compound ſalt was formed. I conſtantly afterwards made the ſolution boil as long as any precipitate appeared, and thus found that 133 grs. of the alkaline ſolution were neceſſary to precipitate the whole of the iron, that is 31,75 grs. of mere alkali, which indicates the preſence of 26,13 of the ſtrongeſt acid or 29,21 of ſtandard.

THE precipitated calx, edulcorated and expoſed to a red heat for three quarters of an hour, weighed 30,5 grs. or rather 31, (as that ſlight loſs may be preſumed during the edulcoration.) This calx was of a deep red colour, and as ſuch calx affords about 72 per cent of iron, theſe 31 grs. were equivalent to 22,3 of metallic iron.

HENCE the proportion of ingredients in 100 parts cryſtallized vitriol of iron are,

Iron - - - -	22,32	parts.
Standard acid - - -	29,21	
Water united to the ſtandard acid -	9,47	
Water of cryſtallization - -	39,00	
	100,00	

HENCE 100 parts iron require 130,85 of the vitriolic ſtandard for their ſolution.

ACCORDING to Mr. Bergman, 100 parts vitriol of iron contain 23 of iron, 39 vitriolic acid, and 38 of water of cryſtallization.

THIS account may eaſily be reconciled to mine, by ſuppoſing what is certainly true, that what he calls the acid part, is not of the ſame ſtrength as the part that is ſo called in tartar vitriolate, but is only that part which does not include the water of cryſtallization. For if we add the 9,47 parts water united to the ſtandard acid to the 29,21 of ſtandard, we ſhall have 38,68 of an acid, whoſe ſpecific gravity is 1,7178.

Mr. Wenzel gives no account of the compoſition of vitriol, but barely relates that 240 grs. of *his* ſpirit of vitriol diluted with 240 of water diſſolved 55,25 of ſteel. Now we have already ſeen that 240 grs. of his ſpirit of vitriol contain 84,19 of my ſtandard, and hence it would appear that 100 parts ſteel ſhould require for their ſolution 152 of vitriolic ſtandard. This ſeeming deviation from my reſult is to be attributed to his having expoſed to the action of the acid a larger proportion of iron than it could diſſolve, the undiſſolved part neceſſarily retained a portion which he could not eſtimate.

To diſſolve iron rapidly the quantity of water ſhould be to that of the ſtandard as 5 to 1; if it exceeds the proportion of 7 to 1 the ſolution will be very ſlow.

Of the Quantity of real Acid in the different Standards.

By *real* acid, I do not mean an acid abſolutely diveſted of all water; perhaps water may be eſſential to the acid properties of all acids, as it certainly is of ſome of them; I barely denote by that appellation the ſtrongeſt acid known to exiſt, whether in a combined or in a ſeparate ſtate; for inſtance, the vitriolic acid, as it exiſts in tartar vitriolate; by recurring to the obſervations made in treating of that ſalt, cubic nitre and ſalt of ſylvius, we ſhall find that

100 parts vitriolic ſtandard contain - - 10,71 of water,
100 parts nitrous ſtandard contain - - 26,46 of water,
100 parts marine ſtandard contain - - 48,5 of water.

THE portions of water here mentioned are ſuperfluous to the conſtitution of theſe different acids, which as we have ſeen may exiſt without them; hence we may find the quantity of real acid included in any quantity of ſtandard; in vitriolic acid by multiplying the quantity of ſtandard into 0,1071, in nitrous acid by multiplying into 0,2646, &c. and ſubſtracting the product from the given quantity of ſtandard.

TABLE I.

Of the Proportion of Acid abſorbed by different Baſes.

100 Parts.	Vitriolic Acid. Standard.	Nitrous Acid. Standard.	Marine Acid. Standard.	Vitriolic Acid. Real.	Nitrous Acid. Real.	Marine Acid. Real.
Pure Vegetable alkali -	92	120	115	82,1	88,3	59,3
Mineral alkali -	143	171	145,92	127,7	136	75,19
Volatile alkali -	227	327	247	202,6	240,4	127,25
Lime - -	124	258,5	104,72	110,6	190	53,94
Magneſia - -	194	286	215,8	173,2	210,33	111,2

TABLE II.

Of the Proportion of Baſis abſorbed by the different Acid Standards.

100 Parts.	Vegetable Alkali.	Mineral Alkali.	Volatile Alkali.	Lime.	Magneſia.
Vitriolic acid - - -	108,7	70	44	80,6	56,6
Nitrous Acid - - -	83,33	58,4	30,58	38,4	34,9
Marine acid - -	87	68,5	40,48	95,4	46,3

TABLE III.

Of the Proportion of Baſis abſorbed by the different Real Acids.

100 Parts.	Vegetable Alkali.	Mineral Alkali.	Volatile Alkali.	Lime.	Magneſia.
Vitriolic Acid - - -	121,8	78,3	49,3	90,4	57,7
Nitrous Acid - - -	113,2	73,5	41,2	52,6	47,6
Marine Acid - - -	168,6	133	78,5	185	89,9

I do not pretend that theſe numbers are rigorouſly exact, for many decimals are omitted, to ſay nothing of inevitable errors, but I think them uſeful approximations.

TABLE

TABLE IV.

Of the Proportion of Ingredients in different Salts.

100 Parts.	Alkali.	Water of cryſtallization.	Acid *.
Tartar vitriolate -	55	—	45 equivalent to 50,49 ſtandard.
Nitre - -	46,15	—	53,85 equivalent to 55,7 ſtandard.
Salt of Sylvius -	64,2	—	35,8 equivalent to 73 ſtandard.
Glauber's ſalt -	24,16	41,3	34,54 ſtandard.
Cubic Nitre -	42,35	—	57,65 equivalent to 78,33 ſtandard.
Common ſalt -	53	—	47 equivalent to 77,33 ſtandard.
Vitriolic ammoniac -	27,42	10,11	62,47 ſtandard.
Nitrous ammoniac -	24	—	76 equivalent to 78 ſtandard.
Common ſal ammoniac	27,62	3,89	68,49 ſtandard.
	Earth or Metal.		
Selenite - -	34	23	43 ſtandard.
Epſom - -	17	50	33 ſtandard.
Allum - -	29,37	44	26,63 containing 19,78 ſtandard.
Vitriol of iron -	22,32	39	38,68 containing 29,21 ſtandard.

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* The acid here mentioned is ſometimes the ſtrongeſt, and ſometimes intermediate between the ſtrongeſt and ſtandard, but its ſtrength may always be known by its relation to the ſtandard.

By viewing the quantity of each ſpecies of real acid taken up by any particular baſis, in the firſt table. it is eaſy to perceive that this quantity does not exactly follow the hitherto preſumed order of affinities between that baſis and the different acids, as I had ſtated it to do in a prior diſſertation. My former opinion was grounded, it is true, on experiments, but thoſe experiments themſelves were accompanied with inaccuracies unſuſpected not only by myſelf but by all other experimenters, and moreover combined with an hypotheſis relative to the quantity of real acid, which I have ſince found to be fallacious. Mr. Morveau, however, in a very maſterly diſſertation on affinities, publiſhed in the New *Encyclopedie*, has among many juſt exceptions to my theory made ſome few obſervations which do not appear to me to be well founded. As the remarks I have occaſion to make thereon are intimately connected with the ſubject of this paper, and tend to illuſtrate it, I hope I ſhall need no other apology for introducing them.

Firſt, I mentioned on a former occaſion, that, according to Mr. Bergman, alkalies took up more of the vitriolic than of the nitrous acid, and more of this than of the marine; but that, according to Mr. Wenzel and Dr. Plummer, this did not happen. Mr. Morveau thinks this obſervation unfounded. The following table will enable the reader to decide. As Dr. Plummer was unacquainted with fixed air, and conſequently made no allowance for it, I ſhall omit his experiments, and in their room exhibit thoſe of Mr. Wiegleb, who being acquainted with the opinion of Mr. Bergman, and with the method he propoſed for making theſe experiments, purſued that method exactly, with a view of aſcertaining the fact in queſtion.

		By Bergman.	By Wenzel.	By Wiegleb.
100 Parts Pure vegetable alkali take up of	Vitriolic acid -	78,5	82.63	101,92
	Nitrous acid -	64	107,8	115,3
	Marine acid -	51	54,46	25,3
100 Parts Mineral alkali take up of	Vitriolic acid -	177	125,87	129,3
	Nitrous acid -	135,5	166,6	139
	Marine acid -	125	83,91	87,5

Here it is evident that both Meſſrs. Wenzel and Wiegleb agree in aſſerting that both alkalies take up more of the nitrous than of the vitriolic acid, contrary to the aſſertion of Bergman. Mr. Morveau allows this as to Wenzel, but thinks that he was miſtaken, yet he follows exactly the method of Bergman. Mr. Morveau thinks that nitre and cubic nitre, when barely melted, retain a conſiderable portion of water, which Mr. Wenzel added to the portion of acid they contain; but it is certain, that inſtead of loſing water in ſuch heats they loſe part of their acid, and conſequently this ſhould be diminiſhed rather than increaſed. Nor does it appear that Wenzel applied a lower a lower heat than Bergman, and it is certain that Wiegleb conſtantly applied a red heat.

SECONDLY, In a paper on the attractive powers of acids, inſerted in the tranſactions of the Royal Society for 1783, I obſerved that the characteriſtic mark of *ſaturation* conſiſted in the loſs of ſome peculiar property of the ſaturating bodies, and that *neutralization* expreſſed the ſaturation of each of the combined principles; as an inſtance of the firſt I adduced the caſe of the ſaturation of an acid, which is judged to take place when it loſes the property of reddening certain vegetable blues, this being the teſt univerſally applied and admitted in this caſe. This inſtance Mr. Morveau thinks not ſufficiently preciſe, for in this ſenſe he thinks there ſhould exiſt combinations without ſaturation, which is repugnant to the principles of affinities, and contrary to obſervation; thus, ſays he, " there is a preciſe term for the combination of a concrete acid with water, and of a concrete acid with a fluid acid, and yet the property of affecting colours is far from being effaced." As to the firſt inſtance, I do not think that an acid can be ſaid to be ſaturated with water (an expreſſion indeed very unuſual) as long as it retains its tinging property; and as to the ſecond, I confeſs I am not acquainted with the effects of the affinities of acids to each other.

" BUT (continues Mr. Morveau) it cannot be doubted but a " mutual ſaturation takes place in cream of tartar and other " ſalts that take up an exceſs of acid between thoſe ſalts in " their neutral ſtate and that exceſs, and yet they affect Tourn-" ſole." In this caſe I allow the neutral ſalts are indeed ſaturated and ſuperſaturated with the acid, but I am far from thinking that the ſuperabundant acid is ſaturated with the neutral ſalts; a ſure ſign that it is not ſo ſaturated is, that if it be duly preſented to a further quantity of the ſame neutral ſalt it will be divided between them.

Application of the foregoing Principles to miſcellaneous Experiments.

THE determination of the quantity of ſtandard or real acid in mineral acids, and that of the proportion of ingredients in neutral ſalts, being ſubjects of great nicety, the firſt never before undertaken by any, and the ſecond undertaken only by a few, and affording diſcordant reſults, neceſſarily inſpire diffidence, until the accuracy of ſome of theſe reſults be confirmed by collateral and general experience. To remove theſe doubts, by proving that my principles accommodate themſelves to the moſt exact experiments hitherto made, I have already quoted the experiments of Mr. Cavendiſh, and ſhall now produce a few made by Meſſrs. Berthollet, Morveau and Woulfe.

Mr. Berthollet* took 288 grs. of nitre and 72 of ſulphur; after expoſing them to a ſufficient heat he found 12 grs. of ſulphur ſublimed, and in the retort 228 grs. of tartar vitriolate. He already proved in a preceding memoir†, that nitre is entirely decompoſed by ¼ of its weight of ſulphur, which is the proportion here employed, therefore we muſt ſuppoſe that 288 grs. of nitre contained as much alkali as 228 of tartar vitriolate, and no more. Now by my computation 288 grs. of nitre contain 132,96 of mere alkali, and 228 grs. of tartar vitriolate contain 125,4. So that if I am miſtaken, it is in attributing too much and not too little alkali to nitre, and my error is only 7,6 grs. in 288 of nitre, or 2,6 per cent.

By Mr. Bergman's computation 288 grs. of nitre contain 141,12 of alkali, and 228 grs. of tartar vitriolate contain only 118,56; ſo that his error amounts to 22,56 grs. in 288 of nitre, or 7,8 per cent.

I now proceed to examine the accuracy of our reſpective computation of the proportion of acids in theſe two ſalts, ſtill taking Mr. Berthollet's experiment as the criterion.

In this experiment the ſum of the ingredients was 288+72 =360 grs., but the ſum of the products was only 288+12 =240 grs.; therefore 120 were loſt or diſſipated in air. And

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* Memoirs, Par. 1782, p. 603.

† Mem. Par. 1781, p. 232.

Mr. Berthollet, in a prior experiment, found this air to be nitrous mixed with a ſmall quantity of pure air. Now by my computation 288 grs. of nitre contain 155,08 of nitrous acid, which is the ſubſtance, of which part is diſſipated in air, and of which part acidifies the ſulphur, and 155,08—120=35,08, this then is the quantity which on my principles ſhould be taken up by the 60 grs. of ſulphur which are converted into vitriolic acid, and 60+35,08=95,08 ſhould be the quantity of acid that ſaturates the alkali of 228 grs. of tartar vitriolate; but again, by my own computation 228 grs. tartar vitriolate contain 102,6 of the ſtrongeſt acid; ſo that the difference between Mr. Berthollet's experiment and the reſult afforded by my computation is only 7,52 grs. in 360 of ingredients, that is only 2,09 per cent. By Mr. Bergman's computation 288 grs. of nitre contain but 95,04 of nitrous acid, which is palpably erroneous, as this amount does not even equal the loſs, this being 120 grs. as we have juſt ſeen; beſides, 228 grs. of tartar vitriolate contain by him 91,2 of vitriolic acid; of this quantity, in this caſe, the ſulphur furniſhes 60 grs. and the remainder, that is 31,2 grs. (the acidifying principle) is furniſhed by the nitrous acid, all the reſt of the nitrous acid, viz. 60 grs. ſhould be loſt or diſſipated, conſequently the loſs ſhould be 60 grs.; but by the experiment it amounts to 120, therefore in every point of view the computation is erroneous. By this experiment it appears that 60 grs. ſulphur are acidified by 35 or 36 of pure air or 100 grs. of ſulphur by 60 of pure air, forming therewith 160 grs. of vitriolic acid. Hence 100 grs. of this acid in its ſtrongeſt

ſtate

ſtate ſhould contain 37,5 of the acidifying principle, the remainder being ſulphur; but as ſulphur is capable of different degrees of acidification, the limits of the quantity of pure air taken up by 100 grs. of it ſeem to be 50 and 60.

Mr. Berthollet attempted to find the compoſition of vitriolic acid in another manner. He boiled 288 grs. of ſulphur in ſtrong nitrous acid; 199 grs. remained untouched, 89 only were acidified. He diluted the whole, and dropped into the liquor the ſolution of marine baroſelenite, and thus obtained a precipitate, weighing after calcination 920 grs. Now according to Bergman this ſalt contains 0,15 of its weight of the ſtrongeſt vitriolic acid*, therefore 920 grs. of it contain 138. This reſult does not differ much from the laſt, for if 100 of ſulphur afford when acidified 160 of the ſtrongeſt acid, 89 parts ſulphur ſhould afford 142. The acidification then is ſomewhat ſlighter.

This excellent chemiſt proceeded ſtill further; he endeavoured to find the quantity of this ſtrong acid in oil of vitriol, whoſe ſpecific gravity was 1,7881. With this view he poured 288 grs. of this acid into a ſolution of lead in the nitrous acid, the precipitate exactly dried weighed 792 grs. Now according to Mr. Bergman vitriol of lead contains 0,28 of its weight of vitriolic acid when exactly dried‡, therefore in this caſe 792 contained 221,76

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* Bergman, p. 420.

‡ 1 Bergm. p. 105. It is true he elſewhere ſays it contains 0,3 of its weight of acid, but that is when it is dried in the heat of 212°. See 2 Berg. p. 392 and 406.

221,76 parts of the ſtrongeſt acid, therefore 288 grs. of oil of vitriol, whoſe ſpecific gravity is 1,7881, contain 221,76 grs. of the ſtrongeſt acid, that is 77 per cent. I do not know at what temperature the ſpecific gravity was taken, but ſhall ſuppoſe it to be at 15° of Reaumur, as is very uſual in France, that is 65,°75 of Farenheit, its ſpecific gravity would then be 1,7917, at the temperature of 60°, for which my table was formed, and conſequently ſhould contain 83,6 grs. of ſtandard. Now 77 grs. of the ſtrongeſt acid are equivalent to 86,4 ſtandard, for 82.92::77.86,4, therefore the difference of Mr. Berthollet's reſult and that afforded by my table is only 2,8 grs. and if the chance of an error in both our reſults be equal, the difference will be only 1,4 gr.

I MUST not diſſemble however that there is an experiment of Mr. Morveau's totally irreconcileable with my table*: He took 58 grs. of vitriolic acid, whoſe ſpecific gravity in the temperature of 8,5 of Reaumur, equal 51°,12 of Farenheit, was 1,841, and dropped into it a ſolution of acetous baroſelinite; he found the precipitate, after calcination in a red heat for half an hour, to weigh only 110,3 grs. which according to Bergman indicates 16,54 of the ſtrongeſt vitriolic acid in the 58 grs. of the oil of vitriol; and if 58 contain but 16,54, 100 grs. of this oil of vitriol ſhould contain but 28,5 of the ſtrongeſt acid, or 32 of ſtandard.

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* Encycloped. p. 592.

This experiment I make bold to ſay is fallacious, for the acid whoſe denſity at 51° was 1,841 ſhould have diminiſhed only to 1,836 in the temperature of 60°, and 100 grs. of it ſhould then contain 87,5 ſtandard, or 77,99 of the ſtrongeſt acid. The concluſion from this experiment is therefore not only incompatible with my own but with that of Mr. Berthollet juſt mentioned, and I believe the cauſe of this miſtake lay in his having poured the barytic ſolution into the acid inſtead of pouring the acid into the barytic ſolution, as Mr. Berthollet had done in precipitating the ſolution of lead, or not applying a ſufficiency of acetous baroſelinite.

The next inſtance I ſhall produce, of the agreement of my principles with the moſt exact experiments, is the decompoſition of common ſalt with the reſulting products, as accurately executed as ingeniouſly contrived by that moſt ſkilful manipulator and ſcientific chemiſt Mr. Woulfe, in the Philoſophical Tranſactions for the year 1767. In his third experiment he employed 14 lbs. avoirdupois of common ſalt and 14 lbs. of oil of vitriol, which had been previouſly diluted with 7 lbs. of water, and diſtilling the mixture with a gentle heat, gradually increaſed, he obtained, in the immediate receiver denoted in his plate by the letter C, 11 lb. 10 oz. of ſpirit of ſalt, and found the more diſtant receivers or bottles containing water deſtined to condenſe the more volatile fumes to have increaſed in weight 3 lb. 10 oz. and the reſiduum in the retort to have weighed 19 lbs. 4 oz. all avoirdupois weight.

Thus

Thus - Ingredients employed.	lbs.	Products obtained.	lbs.	oz.
Oil of vitriol -	14	Spirit of ſalt in the receiver C -	11	10
Common ſalt -	14	Condenſed vapours of do. in bottles	3	10
Water -	7	Reſiduum in the retort - -	19	4
Total -	35	Total -	34	8
		Loſs -	—	8
			35	—

HENCE it is plain that 7 lbs. of water were diſperſed among all the products.

To diſcover the relative ſtrength of the marine acid in the different receivers Mr. Woulfe made the following experiments:

FIRST, 4 ounces of oil of vitriol, whoſe weight was to that of water as 24 to 13, ſaturated 1 lb. 10 oz. 7 drs.=11566 grs. of a fixed alkaline ſolution, which ſerved as a teſt, and which I ſuppoſed to have been formed of vegetable alkali.

SECONDLY, 4 ounces of the ſpirit of ſalt in the receiver C ſaturated 12,5 of that alkaline ſolution.

THIRDLY, 4 ounces of the condenſed vapours, that is, a quantity of water which contained ſo much condenſed vapour, ſaturated 38 ounces of the alkaline ſolution.

Fourthly, To diſcover the proportion of vitriolic acid carried over with the marine in his different receivers, he ſaturated 4 ounces of each product with whiting, taking up the undiſſolved part with diſtilled vinegar, by theſe means he found that 4 ounces of the ſpirit of ſalt in the receiver C afforded half an ounce and 24 grs. of dried ſelenite, but the bottles (or more diſtant receivers) contained none.

THEORY.

I must firſt premiſe that the ſpecific gravity of the oil of vitriol employed in decompoſing the common ſalt is not mentioned; ſince it is not, I muſt ſuppoſe it to be the ſame as that he employed in ſaturating the alkaline ſolution, whoſe weight being to that of water as 24 to 13, its ſpecific gravity, if taken at 60°, was 1,8461, which indicates by my table 88,3 per cent. ſtandard,

	grs.
Conſequently four ounces Avoirdupois - -	=1750
Contained of ſtandard acid 1750×0,883 - -	1545
And ſince 100 parts pure vegetable alkali take up 92 of the vitriolic ſtandard, the quantity of alkali requiſite to take up 1545 of vitriolic ſtandard is - - - -	1680
Therefore 11566 of the alkaline ſolution, ſaturated by this acid, contained of mere alkali -	1680

Again,

	grs.	lb.	oz.
Again, 4 ounces of the ſpirit of ſalt contained in the receiver C afforded 242,7 grs. of ſelenite; and ſince 100 grs. ſelenite contain 43 of ſtandard vitriolic acid, 242,7 contain - - - -	104		
Conſequently the 11lb. 10 oz. of ſpirit of ſalt in the receiver C = 186 ounces, contained of vitriolic ſtandard - -	4852		
14lbs. of oil vitriol contained 14×7000 -	=98000		
And ſince 100 grs. of it contained 88,3 ſtandard, 98000 grs. of it muſt contain of ſtandard - - - -	86534		
Deduct the quantity of ſtandard that paſſed into the receiver C - - -	=4852		
There remained in the retort - -	81682		
Again, the quantity of common ſalt was 14 pound, equal to - - -	98000		
And as 100 grs. common ſalt contain 53 of mineral alkali, the quantity of mineral alkali in this experiment was 98000×0,53, equal to - - - -	51940		
To which, adding the ſtandard vitriolic acid left in the retort, we have 5940×81682 equal the reſiduum, equal	138474=	19	12,5

Which differs from Mr. Woulfe's reſult by 8,5 ounces in exceſs, which difference may be owing to his having uſed an oil of vitriol weaker than I ſuppoſed, and conſequently containing leſs ſtandard, and to his uſing a common ſalt not perfectly pure, but containing marine Epſom, whereas my calculation is grounded on the ſuppoſition of its being perfectly pure. And laſtly, he takes no notice of any fraction of a pound leſs than an ounce; and when all the calculations here employed are conſidered the difference of 8 in 308 oz. will appear inconſiderable.

	grs.
Further, ſince 100 parts pure mineral alkali take up 143 of the vitriolic ſtandard, 51940 ſhould take up -	74274
And deducting this from 81682 in the retort, we find an exceſs of - - - - -	7408

In effect, though Mr. Woulfe ſays nothing of the ſtate of the reſiduum, yet Mr. Baumé, who uſes the ſame proportion of ingredients, obſerves there is always an exceſs of vitriolic acid left in the retort.

I now proceed to examine the quantity of marine acid produced: Since 11566 grs. of the alkaline ſolution contained (as already ſaid) 1680 of mere alkali, 12,5 oz. (=5468,75 grs.) contained	794,35

	grs.
This therefore would have been the quantity of pure vegetable alkali, ſaturated by 4 ounces of the marine acid contained in the receiver C, had it not been mixed with vitriolic acid; but we have already ſeen that theſe 4 ounces contained 104 grs. of the vitriolic ſtandard; and ſince 100 parts vitriolic ſtandard take 108,7 of mere vegetable alkali, 104 grs. of this ſtandard ſhould take	113,04
Conſequently there remained to take up the marine acid only 794,35—113,04	=681,31
And ſince 100 grs. pure vegetable alkali require to ſaturate them 59,3 of the ſtrongeſt or real marine acid, 681 require	404
Therefore 4 ounces of the ſpirit of ſalt in the receiver C contained 404 grs. of the ſtrongeſt marine acid; but the receiver C contains in all 11 lb. 10 oz.=186 oz. of this ſpirit of ſalt; and ſince 4 ounces contained 404, 186 oz. muſt have contained	18786
Again, the 4 ounces of condenſed vapors, that is to ſay as much water as contained 4 ounces of thoſe vapors, ſaturated 38 of the alkaline ſolution, which 38 ounces muſt, from what has been above ſaid, have contained of pure alkali	2414
And ſince 100 grs. mere alkali take 59,3 of the ſtrongeſt marine acid, 2414 muſt have taken	1631

	grs.
But the whole quantity of condenſed vapors was 58 ounces; and ſince 4 ounces contained 1631 grs. of mere acid, 58 ounces muſt contain - -	23649
Hence the whole quantity of real acid was 18786+23649, equal - - - -	42434
Now by my computation 14lbs. of common ſalt =98000 grs. ſhould contain of acid - -	46060
For 100 contains 47. Difference - -	=3626
Then the loſs is 3626 grs.; but, per Mr. Woulfe, the loſs is 8 ounces - - - - -	=3500
Difference between Mr. Woulfe's experiment and my theory - - - - - -	=126